THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 34 DECEMBER 1912 NUMBER 12

ANNUAL MEETING

The Annual Meeting will be in progress as this number of The Journal reaches the membership. There are to be sessions under the direction of several of the sub-committees of the Committee on Meetings, by means of which a total of nine sessions have been arranged, and a greater variety of topics will be treated than at any previous meeting. In the last issue of The Journal a tentative program was published, with a partial list of the papers. The complete program is now given with the full list of papers and a statement of the various social events. In view of the fact that the date for the awarding of the John Fritz Medal by the four engineering societies is Thursday night of the convention, the Council have arranged for this event to take the place of the usual reunion.

There will also be the usual excursions, and a Ladies Committee has been formed to care for the entertainment of the visiting ladies.

PROGRAM

TUESDAY, DECEMBER 3

Opening Session, 8.30 p.m., Auditorium

President's Address, The Present Opportunities and Consequent Responsibilities of the Engineer. Alex. C. Humphreys

Report of Tellers of Election of Officers
Introduction of the President-elect

Reception

Reception by the President and President-elect and ladies, to the members and guests of the Society. A collation will be served at 10 o'clock.

WEDNESDAY, DECEMBER 4

Business Meeting, 10.00 a.m., Auditorium

Annual business meeting. Reports of the Council, tellers of election of membership, standing and special committees. Amendment to Constitution under C57, relating to election of members and membership grades. New business.

SIMULTANEOUS SESSIONS FOLLOWING BUSINESS MEETING

Power Plant Session, Auditorium

DIMENSIONS OF BOILER CHIMNEYS FOR CRUDE OIL, C. R. Weymouth
TESTS OF A 1000-H.P. 24 TUBES HIGH B. & W. BOILER, B. N. Bump
AIR IN SURFACE CONDENSATION, George A. Orrok
PROPERTIES OF SATURATED AND SUPERHEATED AMMONIA, Wm. Earl Mosher
PHYSICAL PROPERTIES OF ANHYDROUS AMMONIA, L. S. Marks and F. W. Loomis

Presented through the courtesy of The American Society of Refrigerating Engineers

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER, Calvin W. Crouch
THE BALTIMORE SEWERAGE PUMP VALVE, A. F. Nagle

This session if necessary will be continued in the afternoon

Textile Session, Sixth Floor

(Papers contributed by Sub-Committee on Textiles)

THE PRINCIPLES OF VALUING PROPERTY, Henry K. Rowell
THE POWER PLANTS OF TEXTILE MILLS, John A. Stevens

Gas Power Section, Sixth Floor

Transaction of business and election of officers
Chairman's Address, RECENT DEVELOPMENT OF GAS POWER IN EUROPE, H. J. Freyn
Discussion by Wm. T. Magruder, D. G. Baker, and others
HEAVY OIL FOR USE IN INTERNAL-COMBUSTION ENGINES, Irving C. Allen

WEDNESDAY AFTERNOON

Reports of Technical Committees, 2.00 p.m., Auditorium

At this session will be presented reports of special committees, including Power Tests, Hoisting and Conveying, Standard Cross-Section Symbols, Involute Gears, Standardization of Catalogues, Flanges, Pipe Threads, and others.

WEDNESDAY EVENING

Reception and Dinner to Professor Sweet, 6.30 p.m., Fifth Floor

A reception and subscription dinner will be tendered to Prof. John E. Sweet, Honorary Member and Past-President, in celebration of his eightieth birthday and in recognition of his services to the engineering profession. Dinner at 7 o'clock.

THURSDAY, DECEMBER 5

Joint Session in charge of Sub-Committees on Machine Shop Practice and Iron and Steel, 10.00 a.m., Auditorium

(Papers contributed by Sub-Committee on Machine Shop Practice)

Report of Sub-Committee: The Development of Machine Shop Practice during the Last Decade

The Vauclain Drill, A. C. Vauclain and Henry V. Wille

Efficient Production of Cylindrical Work, C. H. Norton

Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Sanford A. Moss

To be presented by title. Contributed through the courtesy of the Boston Local Committee

Investigation of Efficiency of Worm Gearing for Automobile Transmission, Wm. H. Kenerson

The Strength of Gear Teeth, Guido H. Marx

(Paper contributed by Sub-Committee on Iron and Steel)

Case Carbonizing, Marcus T. Lothrop

This session if necessary will be continued in the afternoon

Railroad Session, 10.00 a.m., Sixth Floor

(Papers contributed by Sub-Committee on Railroads)

Lighting of Passenger Equipment in Steam Railway Service, H. A. Currie and B. F. Wood

Factors in the Selection of Locomotives in Relation to the Economics of Railway Operation, O. S. Beyer, Jr.

Cement Session, 10.00 a.m., Sixth Floor

(Papers contributed by Sub-Committee on Cement Manufacture)

Some Remarks on the Depreciation Factor in the Cost of Producing Portland Cement, Frederick H. Lewis

Discussion by G. S. Brown

The Prevention of Missed Fires in Blasting, W. H. Mason

The Deterioration and Spontaneous Combustion of Gas Coal, Perry Barker

THURSDAY AFTERNOON

Session on Fluid Flow, 2.00 p.m., Sixth Floor

Measurement of Air in Fan Work, Chas. H. Treat

The V-Notch Weir Method of Measurement, D. Robert Yarnall

To be presented by title. Contributed through the courtesy of the Philadelphia Local Committee

The Centrifugal Blower for High Pressures, Henry F. Schmidt
Measurement of Natural Gas, Thos. R. Weymouth

THURSDAY EVENING

Award of the John Fritz Medal for 1912, 8.30 p.m., Auditorium

The John Fritz Medal for 1912 is to be conferred upon Robert Woolston Hunt, Past-President of the Society, "for his contributions to the early development of the Bessemer process." Following the ceremonial will be a joint reception to Mr. Hunt and to the members and ladies of the four American Engineering Societies.

FRIDAY, DECEMBER 6

Administration Session, Auditorium, 10.00 a.m.

Report of Sub-Committee on Administration. The Present State of the Art of Industrial Management

Axioms Concerning Manufacturing Costs, Henry R. Towne
Measuring Efficiency in Manufacturing, Edward B. Passano

To be presented by title. This session if necessary will be continued in the afternoon

MEETING IN GERMANY

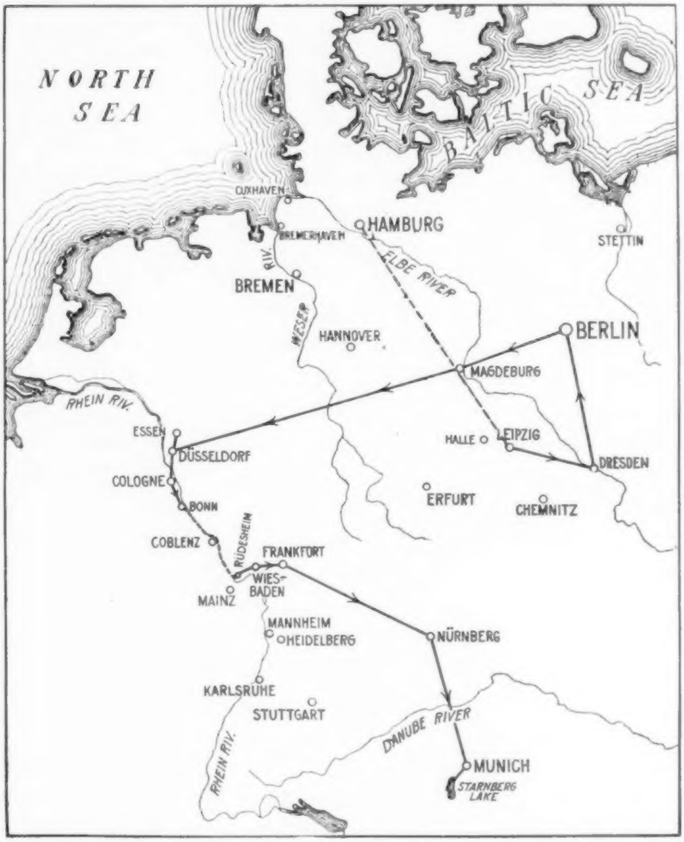
The plans for the meeting of the Society with the Verein deutscher Ingenieure, which promises to be the most remarkable tour of the industries in Germany ever offered to American engineers, continue to go forward actively. Mr. Conrad Matschoss, Dozent of the Royal Polytechnic High School of Berlin who recently visited the United States as a representative of the German society, conferred with the Committee of Arrangements, Col. E. D. Meier, chairman, as to itinerary, professional papers, etc., with most gratifying results.

Owing to the great success of this meeting in which it is probable that many members of the Verein themselves will want to participate, advice has been received by cable that the American party must be limited to 200 members and 100 ladies, since any number in excess of this cannot be accommodated in the hotels of the cities visited. This necessitates the restriction of the party to members only and the ladies of their immediate family. As the number of those who have already signified their intention of joining the party now nearly equals this, any opportunities for participating which may arise must be accorded in the order in which requests are received in the office of the Secretary.

The date of the departure will be June 10 on the Hamburg-American liner Victoria-Luise, arriving in Hamburg on Saturday, June 21. Here the party will be received by the municipal authorities at the point of landing and given an opportunity to visit the great shipyards before going on by special train to Leipzig the same or the following day. Sunday evening, the 22nd, will be the occasion of an informal gathering to promote acquaintanceship, preceding the more formal opening on Monday, June 23. At this opening there will be a welcome by the King of Saxony and the municipal authorities of Leipzig, and two addresses, one by a representative of the German and the other by a representative of the American Society, which will be on general subjects, such as the history of engineering, the relation of capital and labor, and the effect

on industry of technical education. Tuesday, the last day to be spent in Leipzig, will be devoted to technical papers and to various social events and participation in the patriotic gathering in commemoration of the one-hundredth anniversary of the battle of Leipzig.

The party will leave on Wednesday for a tour of industrial



Itinerary of Official Tour in Germany, June 23-July 7, 1913

Germany visiting the principal cities, such as Dresden, Berlin, Düsseldorf, Cologne, Frankfurt a/M., Nürnberg, Munich, etc. In all probability the Krupp works at Essen will be thrown open to the party, the Baroness von Bohlen (geborene von

Krupp) receiving the visiting American engineers in person. The trip up the Rhine from Bonn to Rüdesheim will be made by boat and at Rüdesheim there will be a grand festival on the embankments. Independence Day will be celebrated at Frankfurt a/M. under the auspices of the American embassy.

The final meeting will be held in Munich, July 7, in connection with the Museum of Technical Arts, of which Dr. von Miller is the Director. It is expected that the Prince of Bavaria and the Mayor of Munich will also receive the party. The entire trip through Germany and the various official receptions are being arranged by a committee of the most important men of the arts and sciences in the German society and there is the keenest interest shown by municipal authorities and the heads of industrial establishments.

The itinerary of the visit will be as follows:

TENTATIVE PROGRAM

June 21 Reception at Hamburg by the local board

June 22 (Sunday) Leipzig, official reception by the Verein deutscher Ingenieure

June 23, 24 Participation in the exercises of the 54th Annual Meeting of the Verein deutscher Ingenieure

June 25, a.m. Dresden

June 27, 28 Berlin

June 29 Düsseldorf. Reception by the Rhine-Westphalian Section of the Verein

June 30 to July 2 Various functions arranged by the Rhine-Westphalian Section, including a trip to Cologne and Essen

July 3 By railway to Bonn. By boat up the Rhine with festival at Rüdesheim. By rail to Frankfurt a/M., arriving about 6 p.m. Evening: reception of welcome at Frankfurt

July 4 Independence Day at Frankfurt

July 5 a.m. Nürnberg

July 6 p.m. Munich Evening reception of welcome

July 7 a.m. Visit to the German Museum

July 7 p.m. Trip on the Starnberg lake
Final exercises in the Rathhaus

A map illustrating this proposed itinerary is published herewith.

CURRENT AFFAIRS OF THE SOCIETY

The activities of the Society are developing, particularly in the matter of coöperation with other organizations, for the general benefit of the profession, especially along lines of standardization. Members will notice in the report of the Council several committees appointed for specific standardization work, as well as a special committee to advise the Council how we can comprehensively undertake our various duties in this direction.

CONDUCT OF ANNUAL AND LOCAL MEETINGS.

An important and urgent matter before the Society is how we may best conduct our meetings, both general and local, so that members may get the fullest benefit of the Society organization and their interest be maintained, particularly of those who cannot attend the general meetings. The Committee on Constitution and By-Laws have prepared a proposed code, under instruction of the Council, and these Rules and By-Laws, which appear as proposed amendments to the existing By-Laws and Rules, have been issued in pamphlet form to all the standing, geographical and professional committees, with an invitation that comments be sent to the Council. Other members of the Society interested may receive copies of this report upon request. The Council has invited the chairmen of the several committees to attend an informal subscription dinner to be held at the Engineers Club on the evening of Thursday, December 5, for the purpose of discussing these matters fully.

NATIONAL MUSEUM.

Some of our most active members have long desired to see the establishment of a Museum where the development of engineering and the arts might be preserved, and in the original design of the Engineering Societies Building a large room on the twelfth floor was set apart for this purpose, which on account of lack of funds has never been accomplished. The visit of Dr. Oskar von Miller and the commission from Munich of the German Museum, however, has revived this interest with such en-

thusiasm that the Council has appointed a committee to coöperate with other organizations in the establishment of a great National Museum.

1915 ENGINEERING CONGRESS

The Society is more sensitive than ever to the interests of all of its members and takes great satisfaction in the prospect of an International Engineering Congress in San Francisco in 1915 to celebrate the world's greatest engineering achievement, the Panama Canal. As will be seen in the minutes of its last meeting, the Council has been pleased to underwrite this congress to the extent of $5000, or any portion of it which may be its share of the expenses, provided the other American engineering societies similarly participate.

JOHN FRITZ MEDAL

Invitations have been mailed to the entire membership, notifying them of the award of the John Fritz Medal to a Past-President of this Society, Mr. Robert Woolston Hunt. As the award will be made on Thursday evening during our Annual Convention, the Council has decided to omit the annual reunion, as it will on this occasion act as joint host with the American Institute of Electrical Engineers and the American Institute of Mining Engineers to all the members and ladies of the four American engineering societies.

CALVIN W. RICE, *Secretary.*

AMENDMENTS TO BY-LAWS AND RULES

AMENDMENT TO BY-LAW 18

B 18 The Council at any meeting may, in its discretion, permanently remit the dues of any Member of the Society who has paid thirty years' dues, or who shall have reached the age of seventy years after having paid twenty-five years' dues, provided that notice of such proposed action shall have been given at a previous meeting of the Council and the Committee on Membership shall have concurred in recommending that this action be taken. The Council may, in its discretion, restore to membership any person dropped from the rolls for non-payment of dues, or otherwise, upon such terms and conditions as it may at the time deem best for the interests of the Society.

This announcement appeared in the November issue, but with an error in the wording of the By-Law.

AMENDMENTS TO RULES

R 13 The features of the program outside of the professional and business sessions to be provided for the members and guests at any meeting of this Society in any city shall be in charge of a Local Committee, subject, however, to the general approval of the Committee on Meetings. The President's reception of the annual meeting shall be in charge of the House Committee under the general supervision of the Committee on Meetings.

PROFESSIONAL SECTIONS AND GEOGRAPHICAL GROUPS

R 19 A professional section or a geographical group of the Society shall consists of Honorary Members, Members, Associates, and Juniors of The American Society of Mechanical Engineers and of other persons to be designated Affiliates as hereinafter described.

R 20 A professional section of The American Society of Mechanical Engineers may, with the approval of the Council, be organized for the consideration of any engineering, scientific, or professional topic, provided that a number satisfactory to the Council, of members of The American Society of Mechanical Engineers, unite in making written request for such an organization. A similar procedure shall apply to geographical groups. Such a section or group shall be designated as —— Section or —— Group of The American Society of Mechanical Engineers,—the blank being filled by the topic specialized or name of locality.

R 21 The provisions of the Constitution, By-Laws and Rules of The American Society of Mechanical Engineers, and the precedents of the Society with respect to professional sessions for the discussion of papers, shall cover the procedure of the professional sections or geographical groups except that no meeting of a section or group shall be considered a meeting of the Society as a whole.

R 22 For the convenient conduct of its professional affairs the section or group shall organize an Executive Committee of five members of the Society, under the general direction of the Council. Such officers as the section or group shall require must be selected from the membership of the Society. Other committees of the section or group shall be appointed by its Executive Committee.

R 23 The Executive Committee of the section or group, subject to the approval and direction of the Secretary of the Society, shall designate a Secretary of the section or group, whose duties shall be those usually attaching to the Secretary of a profe sional session, and who shall also see that the discussions of papers are satisfactorily reported and transmitted to the Secretary of the Society.

R 24 Expenditures for the purpose of a section or group chargeable to the Society must be authorized by the Secretary of the Society before they are incurred, and must be provided for in the estimate and budget approved by the Council. No liability otherwise incurred shall be binding on the Society. Any expenditure not so provided must be met by the section or group itself.

R 25 Engineers and others not members of The American Society, but desiring to participate in the meeting of the section or group, may enroll

themselves as affiliates as heretofore provided, with the approval of the Executive Committee of the section or group. Such affiliates shall have the privilege of presenting papers and taking part in the discussions. They shall pay $5 per annum, which shall be due and payable in advance, on October 1st of each year of their enrollment, and shall thereby be entitled to receive the regular issues of The Journal for a period covered by their dues.

R 26 The Council of The American Society of Mechanical Engineers may, at sixty days notice, suspend or disband any section or group.

COUNCIL MEETING, NOVEMBER 12

At a meeting of the Council held on Tuesday afternoon, November 12, there were present Alex. C. Humphreys, E. D. Meier, James Hartness, H. G. Reist, Henry Hess, Jesse M. Smith, Ira N. Hollis, F. R. Hutton, E. B. Katte, Wm. H. Wiley, George A. Orrok, R. M. Dixon, and C. W. Rice, Secretary. The following deaths were reported: R. P. Badeau, F. H. Crabtree, A. W. Danforth, S. T. Mudge, J. M. Robinson, A. E. Rowland, George H. Schuete, J. B. Siner and Maunsel White. Resignations were accepted from Percy Allan, C. W. Baker, G. H. Benton, A. S. Blanchard, H. M. Chamberlain, E. D. Church, H. W. T. Collins, Theo. F. Dreyfus, J. H. King, G. P. Lawrence, W. G. Marot, Harris J. Ryan, C. M. Russell, Harry Tandy, Jas. C. Porter, F. H. Burton, A. T. Doud, John R. James, W. A. Schaefer.

Fred J. Miller, chairman, R. M. Dixon, Morris L. Cooke and Carl J. Barth were appointed a Committee on Codification of Office Standards.

Amendments to the Rules, in respect to the conduct of professional sessions and geographical groups, which appear elsewhere in this issue, were passed.

H. G. Stott, A. F. Ganz and Carl Schwartz were appointed a committee to coöperate with the American Institute of Electrical Engineers in the matter of standardization of the new unit of power, the myrowatt.

A committee consisting of A. L. DeLeeuw, Henry Hess and John Riddell were appointed to coöperate with the National Machine Tool Builders Association in the matter of standardization of machine tools.

C. J. Davidson, Newell Sanders, Putnam A. Bates and Wm. Butterworth, were appointed a committee to coöperate with the

Society of Agricultural Engineers in the standardization of agricultural implements.

A committee composed of E. D. Meier, H. G. Reist, Ambrose Swasey, George Mesta, and Geo. F. Kunz was appointed to coöperate with other organizations in the establishment of a National Museum.

A committee consisting of Henry Hess, J. H. Barr, Charles Day, C. J. Davidson and Carl Schwartz, was appointed to advise the Council on the general conduct of the standardization work of the Society.

In connection with the International Congress to be held in San Francisco in 1915, $5000 or such portion of it as may be our share, was ordered underwritten, provided the other American societies make similar provision for this congress.

The Council was very gratified to receive an inquiry from the Milwaukee Engineering Society with respect to affiliation with this Society, and appointed Geo. M. Brill, Vice-President, to extend the greetings of the Society to the Milwaukee organization.

The Secretary was authorized to appoint H. A. Hey assistant to the Secretary, to represent the Secretary in his absence.

The Annual Reports of the Council and Standing Committees were received and referred jointly to the Executive and Publication Committees.

The meeting adjourned to Tuesday, December 3, at two o'clock.

LAND AND BUILDING FUND

Through the willingness of the membership to assume the responsibility of our indebtedness on the land fund of the Engineering Societies Building, our share of this amount has now been paid off, so that the Society may feel itself free to undertake the new activities and responsibilities which confront it.

At a meeting of the Council on June 18, the following action was taken:

WHEREAS direct official acknowledgement has not been made of all the contributions to the Land and Building Fund of the Society and to owners of Certificates of Indebtedness, and only a partial list printed in The Journal, be it

RESOLVED: That an alphabetical list of all contributors to the fund and owners of certificates be printed in an early issue of The Journal, and be it

RESOLVED: That the thanks of the Society are hereby tendered to the contributors to the Land and Building Fund and to the owners of Certificates of Indebtedness, by which The American Society of Mechanical Engineers has been able to discharge its obligations in connection with its participation in the gift by Mr. Andrew Carnegie, Honorary Member of The American Society of Mechanical Engineers of the Engineering Societies Building.

RESOLVED: That the thanks of the Society are hereby tendered to the members of the Land and Building Fund Committees, Messrs. Fred J. Miller, Chairman, James M. Dodge, R. C. McKinney, Committee in 1907; Worcester R. Warner, Chairman, F. H. Stillman (deceased), George A. Orrok, I. E. Moultrop and C. N. Lauer, Committee in 1910; and R. M. Dixon, Chairman, Waldo H. Marshall and Charles Wallace Hunt (deceased), Committee in 1911, with respect to the Certificates of Indebtedness, for the able and energetic manner in which these committees conducted the work intrusted to them, which resulted in securing contributions from 66 firms and 300 members and in placing 163 certificates of indebtedness, aggregating $161,000.

RESOLVED: That copy of these resolutions be sent to the members of each of the above committees.

RESOLVED: That the Society is under special obligation to Charles Wallace Hunt, Past-President, for his wisdom and foresight, after exhausting the opportunities for further contributions, in providing for the discharge of the remaining obligations of the Society, $81,000 by the issue of Certificates of Indebtedness and for the preparation of the presenta-

tion letter with respect thereto, which resulted in an over-subscription.

The list of names is as follows:

CONTRIBUTORS TO LAND FUND

Abbott, W. L.
Abercrombie, J. H.
Alden, G. L.
Allen, W. M.
Allis-Chalmers Co.
Almond, T. R. Mfg. Co.
American Locomotive Co.
American Pulley Co.
Andrews, Jas. D.
Appleton, Wm. D.
Babcock & Wilcox Co.
Baird Machinery Co.
Baker, J. C. W.
Baldwin, Stephen
Bancroft, J. Sellers
Barnes, S. G.
Barnes, W. F.
Barth, Carl G.
Bartlett, Henry
Bates, A. H.
Bates, Edward P.
Bausch, Wm. H.
Baylis, Arthur R.
Beck, Jas. D.
Bettendorf, W. P.
Bickford Drill & Tool Co.
Bilgram, Hugo
Billings, C. E.
Billings & Spencer Co.
Bitterlich, Walter J.
Blauvelt, A.
Borden, W. H.
Bradford Mch. Tool Co.
Brandon, G. R.
Breckenridge, L. P.
Bridgeport Mfg. Co.
Brill, Geo. M.
Brown & Sharpe Mfg. Co.
Brown, A. E.
Brown, A. T.
Brownell Company,
Brush, C. F.
Buckeye Engine Co.
Buckley, J. F.
Bullard Machine Tool Co.
Bump, B. N.
Burlingame, L. D.
Burns, A. L.
Burroughs Adding Mch. Co.
Burton, J. H.
Cadillac Motor Car Company
Calder, John
Caracristi, V. Z.
Carlsson, C. A. V.
Cheney, W. L.
Christie, W. W.
Cinn. Machine Tool Co.
Cinn. Milling Machine Co.
Cinn. Plane Co.
Clegg, Robert I.
Clemens, Chas. W.
Cogswell, W. B.
Coleman, E. P.
Colts Patent Firearms Mfg. Co.
Conard, W. R.
Continental Iron Works
Cooke, Harte
Core, W. Wallace
Cox, J. D.
Cromwell, J. C
Doty, Paul
Dodge, Day & Zimmermann
Dougherty, S. B.
Dow, Alex.
Dreses Machine & Tool Co.
Duncan, J. D. E.
Dunn, J. W.
Dyer, R. A., Jr.
Eberhardt, Elmer G.
Eberhardt, Frank E.
Eberhardt, Henry E.
Eberhardt, Henry J.
Edson, J. B.
Edwards, V. E.
Ekstrand, C.
Ellsworth, J. W. & Co.
Engineering Magazine
Engineering News

Engineering Record
Evans, H. O.
Falkenau, A.
Ferguson, J. W.
Ferracute Machine Co.
Ferry, C. H.
Fish, C. H.
Fleming, H. S.
Fletcher, W. & A. Co.
Flinn, Thos. C.
Flint, Walter
Foote, A. W.
Freeman, John R.
Freeman, S. E.
French, E. V.
Fritz, John
Fuchs, Ernesto
Gabriel, Wm. A.
Gaehr, David
Gamper, H.
Gardiner, A. J., Jr.
Gately, P. J.
Gates, P. H.
Gisholt Machine Co.
Glasgow, A. G.
Gleason Works
Goss, W. F. M.
Green, Wm. O.
Guelbaum, David
Guckel, Chas. H.
Harrington, N. T.
Hartness, Jas.
Haskell, B.
Hayes Mfg. Co.
Hazard, F. R.
Heaton, H. C.
Hecker, H. A.
Heine Safety Boiler Co.
Helmes, M. J.
Henderson, Richard
Henry, George J., Jr.
Herbert, J. S.
Herbert, C. G.
Hess-Bright Mfg. Co.
Hess, Henry
Hubbard, H. D.
Higgins, M. P.
Hill, H. H.
Hill Publishing Co
Hinchman, C. R.
Holcomb, A. E.
Holloway, H. F.
Hosmer, Sydney
Houston, Stanwood & Gamble Co.
Howard, C. P.
Hulett, F. E.
Hulett, G. H.
Hunt, Chas. W.
Hunter, Geo. E.
Huson, W. S.
Hutchinson, Richard
Hutton, F. R.
Idell, Frank E.
Industrial Press
Isham, Henry S.
Jackson, D. C.
Jacobus, D. T.
Jenkins Brothers
Jenks, R. P.
Johnson, C. W.
Johnston, F. W.
Jones, Horace K.
Katte, E. B.
Kelley, Fred W.
Kennedy, F. L.
Kennedy, M. E.
Kennedy Valve Mfg. Co.
Kent, J. M.
Kimber, G. A.
Kirby, Frank E.
Kirchhoff, Chas.
Kwong Yung Kwang
Laird, W. G.
Lane, H. M.
Lange, P.
Lardner, Henry A.
Larner, C. W.
Larsson, T. L. F.
Lauder, G. B.,
Lauer, C. N.
LeBlond, R. K., Mch. Tool Co.
Leland, Henry M
Leonard, E. J.
Lewis, Wilfred
Lidgerwood Mfg. Co.
Link Belt Co.

Little, Chas. H.
Littleford Bros.
Lobben, Peder
Locomobile Co. of America
Lodge & Shipley Mch. Co.
Loring, Chas. H.
Lucas Machine Tool Co
Lunkenheimer Company
Lyall, Wm. L.
MacArthur, Robt. J.
McIntosh, Seymour & Co.
McMillen, Emerson
Machold & Riddell
Magruder, Wm. T.
Main, Chas. T.
Malvern, L. K.
Manning, C. H.
Martell, L. H.
Martin, F. S.
Marx, Henry
Mason, Wm.
Mason, Wm. B.
Mattice, A. M.
Maury, D. H.
Meaker, Guy L.
Meier, E. D.
Melville, George W.
Merryweather, G. E.
Messnick Mfg. Co.
Miller, Fred J.
Miller, Theo. H.
Miller, L. B.
Mix, E. W.
Moeller, F.
Moore, Chas. C. & Co.
Morgan, R. L.
Morrin, Thos.
Morrison, H. S.
Moultrop, I. E.
Mount, W. D.
Murphy, B. S.
Murphy, John K.
Murphy, John Z.
Naegeley, John C.
Nate, E. H.
Neave, P. M.
Newark Gear Cutting Machine Co.
Niles Bement Pond Company
Norris, R. V.
Otis, Spencer
Park, W. R.
Parkhurst, F. A.
Pettis, C. D.
Philbrick, Frank B.
Platt, John
Polson, J. A.
Power, Fred M.
Prather, H. B.
Pratt, Francis C.
Prescott, F. M.
Price, A. M.
Prosser, Jos. G.
Quimby, W. E.
Quint, A. D.
Quintard Iron Works
Reed, E. Howard
Reid, Marcellus
Reiss, George T.
Reist, H. G.
Rhoades, G. E.
Rice, Calvin W., Sec'y
Richter, Ernest
Rider, George S.
Riddell, John
Riggs, John D.
Rivett, E.
Robertson, R. A.
Robeson, A. M.
Roe Stephens Mfg. Co.
Roper, Norman B.
Sargent, Fred'k
Satherberg, Carl H.
Saunders, W. Q.
Saxon, Wm.
Schaeffer, Jos. C.
Scheele, John M. B.
Scheffler, Fred A.
Schneider, Paul E.
Schulte, G. H.
Schwarz, F. H.
Sellers, Wm. & Co., Inc
Sharpe, H. D.
Shirrell, D.
Smith, E. J.
Smith, Jesse M.
Smith, Oberlin

Smith, O. G.
Snow, Wm. G.
Snow, Wm. W.
Solvay Process Co.
Sprado, Ralph
Stanwood, J. B.
Starbuck, G. F
Stetson, G. R.
Stevens, John A.
Stut, J. C. H.
Sulzer, J. Carl
Swasey, Ambrose
Sweet, John E.
Symonds, N. G.
Terry, C. D.
Thomas, Charles W.
Thompson, A. W.
Thompson, John
Tower, D. W.
Tompkins, Stonewall
Torrance, Henry
Towle, Wm. M.
Towne, Henry R.
Triumph Electric Co.
Trump, Edw. N.
Tufts, Leonard
Turner, Charles P.
Turner, John
Tuttle, W. B.
Tyler, Chas. C.
Underwood Typewriter Company
Union Twist Drill Company
United Engrg. & Fdy. Co.
Upson, Maxwell M.
Vauclain, S. M.
Vaughan, H. H.
Veeder, C. H.
Viola, B.
Waitt, A. M.
Wallace, D. A.
Ward, Charles E.
Wards Engine Works
Warren, John E.
Warner, W. R.
Watson-Stillman Company
Weber, H. F.
Wehner, Lewis
Wellman, S. T.
Westinghouse Company
Weymouth, C. R.
Wheeler, C. H.
Whitaker, H. E.
White, John C.
Whitehead, George E.
Whitney Mfg. Co.
Whyte, John S.
Wicks, Henry
Wildin, G. W.
Wiley, John & Sons
Willcox, Chas. H.
Williamson, George E.
Willis, E. J.
Wolf, Fred W.
Wood, Erwin E.
Wood, Walter
Woodbury, C. J. H.
Young, John P.

HOLDERS OF CERTIFICATES OF INDEBTEDNESS

Abbott, W. L.
Abercrombie, J. H.
Alden, G. I.
Alexander, M. W.
Allen, Francis B.
Allison, Robt.
Anderson, J. M.
Appleton, C. B.
Ayers, H. B.
Bailey, H. H.
Baldwin, C. Kemble
Bancroft, J. Sellers
Barr, John H.
Barth, Carl G.
Basford, G. M.
Best, W. J.
Bond, Geo. M.
Bourne, Geo. L.
Bower, E. S.
Brill, Geo. M.
Caracristi, Virginius Z.
Carroll, Elbert H.
Carpenter, J. M.
Chester, J. N.

Christie, W. W.
Clark, F. H.
Cobb, Geo. H.
Colwell, A. W.
Colwell, J. V. V.
Conlee, Geo. D.
Conrad, W. W.
Cooke, Fred. W.
Coster, Edward L.
Daniels, F. H.
Deane, F. W.
Dickerman, W. C.
Dixon, R. M.
Doane, W. H.
Doelling, L. K.
DuPont, L. C.
Durant, W. F.
Dyer, R. A., Jr.
Eaton, H. C.
Ely, Theo. N.
Emerson, Harrington
Emmet, W. L. R.
Estes, Wm. W.
Farquhar, Francis
Fermier, E. J.
Firmstone, F.
Flagg, Saml. B.
Flory, B. P.
Foran, Geo. J.
Ford, Bruce
Foster, C. H.
Fraser, D. Ross
Fraser, Norman D.
Fritz, John
Gantt, H. L.
Garden, H. C.
Gazzam, Joseph P.
Geier, Fred. A.
George, J. T.
Gordon, H. D.
Goss, W. F. M.
Grossmann, A.
Hadfield, R. A.
Hammer, Alfred E.
Hammett, H. G.
Hartness, Jas.
Herbert, C. G.
Herr, E. M.
Herschel, W. A.
Hess, Henry
Hinchman, C. R.
Hoefer, E. J.
Hoffman, J. D.
Holmes, Arthur
Honiss, Wm. H.
Honsberg, August A.
Hoxie, W. D.
Hugo, T. W.
Humphreys, Alex. C.
Hunt, Wm. F.
Hussey, W. E.
Hutchins, Geo. F.
Hutton, F. R.
Jackson, Arthur C.
Jacobi, Albert W.
Jenks, R. P.
Johnstone, F. W.
Jones, H. C.
Libby, Malcolm
Lindstrom, Chas. A.
Longstreth, Chas.
Lucas, H. M.
Lundgaard, I.
Main, Chas. T.
Manning, C. H.
Marks, Lionel S.
Marshall, W. H.
Matheson, W. G.
Meier, E. D.
Melville, G. W.
Merz, Robt. G.
Miller, Fred J.
Morgan, Paul B.
Moultrop, I. E.
Muhlfeld, J. E.
Munson, E. G.
Murphy, Edw. J.
McBride, James
McDewell, H. S.
Nelson, Jas. W.
Nickel, F. F.
Nickerson, Chas. H.
Nickerson, A. T.
Otis, Spencer
Phetteplace, T. M.
Plunkett, Chas. T.

Posey, Jas.
Pratt, Jas. A.
Reid, John S., Sr.
Reiss, Geo. T.
Richter, Ernest
Riddell, John
Ritter, H.
Robinson, A. W.
Rohlig, George G.
Ray, David H.
Royle, Vernon
Sague, J. E.
Sanguinetti, Philip C.
Sando, W. J.
Schwamb, Peter
Schwartz, Carl
Sellers, Coleman, Jr.
Sharpe, Henry D.
Shedd, Frank E.
Small, H. J.
Smith, Augustus
Smith, Harry J.
Smith, Jesse M.
Smith, J. W.
Spalding, C. M.
Spiro, Chas.
Stearns, A. W.
Stafford, B. E. D.
Stetson, G. R.
Stott, H. G.
Stutz, C. C.
Swain, Geo. F.
Swasey, Ambrose
Sweet, J. E.
Taylor, F. W.
Taylor, J. W.
Thompson, O. C.
Towne, H. R.
Tyler, C. C.
Vauclain, S. M.
Viall, W. A.
Wadleigh, Geo. R.
Waitt, Arthur M.
Warren, John E.
Westinghouse, H. H.
Wiley, Chas.
Wiley, Wm. H.
Whyte, F. M.
Zehnder, C. H.

ANNUAL REPORT OF COUNCIL AND STANDING COMMITTEES

REPORT OF THE COUNCIL

The activities of the Society for the year 1911-1912 have covered a wide scope. Prominent among them has been coöperation with other societies. For this purpose a conference committee has been formed, consisting of two appointees each from the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and The American Society of Mechanical Engineers, whose province it is to bring to the attention of their respective organizations for action matters of importance. The Society has also coöperated with other organizations and appointed committees to assist.

A Committee on Engineering Standards has been formed, with which the prominent engineering societies of the world have been asked to coöperate, to establish a clearing house for the issuance of information respecting standards for the engineering profession.

At various functions during the year, the Society has been represented by the following Honorary Vice-Presidents, appointed by the Council: William M. Rice Institute, Houston, Texas, W. B. Tuttle; Fourth National Conservation Congress, George M. Brill and W. B. Jackson; American Electric Railway Association, R. W. Hunt and C. J. Davidson; International Rubber Conference, E. B. Katte; International Conference on Hygiene and Demography, H. de B. Parsons and T. Kennard Thompson; Pratt Institute Commencement Exercises, C. W. Obert; Carnegie Institute of Technology, O. P. Hood; National Waterways Commission, H. G. Stott; International Congress of Navigation, Wm. T. Donnelly; American Academy of Political and Social Science, Geo. W. Melville, C. M. Day, J. M. Rusby.

Ties with organizations abroad as well as at home are con-

tinually being strengthened by the Society's policy of coöperation. During the year the Society has participated in the erection of a memorial window at Westminster Abbey to the memory of Lord Kelvin, under the auspices of the Institute of Civil Engineers, $600 having been subscribed by members of the Society for this purpose. In April of this year, the members of the German Museum Commission appointed to study important engineering achievements in America, were given the greetings of the Society at a meeting in the Engineering Societies Building, and in the various cities visited were assisted by committees of the membership formed for the purpose. An invitation to participate in a meeting of the Verein deutscher Ingenieure in Leipzig in the summer of 1913 has been accepted by the Council and active preparations for the trip have been begun by the Committee of Arrangements, Col. E. D. Meier, chairman.

Within the Society itself new activities have been undertaken. As a result of an earnest consideration by the Council of ways and means of extending the membership, a committee on Increase of Membership, I. E. Moultrop, chairman, was appointed early in the year. This committee has coöperated with the Membership Committee in seeking to invite only those qualified for admission from among those prominent in the profession and if possible increasing rather than lowering in any way the present high standard of membership. The proposed amendments to the Constitution provide an additional engineering grade, making the several grades of membership similar to the more important American and English societies and simplifying the method of election in accordance with these same prominent organizations. The proposed engineering grade is that of Associate-Member, intermediate between Member and Junior, and election by the Council is proposed to be substituted for election by the membership.

Honorary membership has been conferred during the year upon Anatole Mallet of Paris, Carl Gustav Patrick DeLaval, Stockholm, Rudolph Diesel, Munich, and Oskar von Miller, Munich. The death of George Wallace Melville, Past-President and Honorary Member, is reported with regret.

The following table shows the changes in membership for the fiscal year, October 1, 1911, to October 1, 1912, in distinction

from the administration year which the rest of the report covers:

MEMBERSHIP FOR FISCAL YEAR (OCT. 1, 1911–OCT. 1, 1912)

Grade	Oct. 1, 1911	Losses				Additions			Net decrease	Net increase	Oct. 1, 1912
		Transfer	Resignations	Lapsed	Death	Transfer	Election	Reinstatements			
Honorary	16	..	..	..	1	..	3	..	..	2	18
Members	2702	1	19	30	27	54	278	4	..	259	2961
Associates	370	13	4	10	4	2	16	..	13	..	357
Juniors	919	43	17	28	2	1	175	1	..	87	1006
Total	4007	57	40	68	34	57	472	5	..	335	4342
Affiliates Gas Power Section	134	....				....			8	..	126
Affiliates Student Section	635	....				....			..	87	722

The University of California has been added to the list of student branches, which now number 25. The total number of student affiliates is now 722. The Committee on Student Branches has been increased by the addition of Wm. Kent and George A. Orrok, with the intent that through this enlarged committee visits can be made to the several branches.

An important step with reference to local meetings of the Society was taken at the Spring Meeting in Cleveland, after conference with representatives of the several cities where meetings are held. The policy adopted was to extend the rules for professional sections making them applicable to geographical sections. Upon approval of the Council local meetings may now be considered sectional meetings, with the local committee in responsible charge. A close relation between the Society's headquarters and those of the several centers is maintained by the interchange of papers. Under these provisions meetings as sections are now being conducted in San Francisco, St. Louis and Cincinnati.

The Council reports the final adoption of amendments to the Constitution, By-Laws and Rules, which appear elsewhere.

Committee activity has been marked throughout the year and the advance which the Society is making has come about through the earnest work of the standing and special committees. Full details appear in the separate reports of the committees accompanying this report.

The task of completing the series of pictures of Honorary Members has progressed under the care of the House Committee, and twenty-two of these portraits are now hung upon the walls of the Society's rooms. To this committee has been assigned the duties in connection with the President's Reception given each year at the Annual Meeting.

Through the initiative of the Library Committee amendments to the By-Laws of the United Engineering Society have been prepared and have received the approval of the Boards of each of the Societies comprising the United Engineering Society, whereby a common administration of the joint libraries of the American Institute of Mining Engineers, the American Institute of Electrical Engineers and The American Society of Mechanical Engineers, may be secured, making possible greater efficiency in the joint library service, together with symmetry of the several collections, so that there may be no duplication of effort.

An important advance movement has been undertaken by the Committee on Meetings in the appointment of six additional sub-committees, covering various phases of mechanical engineering, with the idea of securing increased service through the assistance of specialists who will report developments in their respective fields. There are now ten of these sub-committees, covering Administration, Air Machinery, Cement Manufacture, Fire Protection, Hoisting and Conveying, Industrial Building, Iron and Steel, Machine Shop Practice, Railroads, and Textiles.

Due to the rapid growth of the Society, the work of the Publication Committee has become increasingly difficult, particularly as regards Transactions, there being sufficient important material to fill a two volume edition. The Council has concurred in the recommendation of the committee that an index to Transactions, comprising volumes 1 to 33 inclusive, be published, and an appropriation has been secured for the purpose. The subscription price of The Journal has been reduced to \$2 a year to members and affiliates and \$3 a year to non-members. This publica-

tion has been entirely self-supporting during the year and has continually sought to enlarge its field of activity and usefulness, so as to present a complete record of mechanical engineering.

A total of 865 applications for membership have been received by the Membership Committee during the fiscal year, of which 694 have been recommended for membership. Eight former members have also been reinstated. The Committee have adopted a more simple form of application and reply blank which will more readily meet its requirements.

A special committee on Code of Ethics has been appointed by the Council, following the example of other societies, to consider the formation of such a code.

The special committee on Flanges has coöperated with the National Association of Master Steam and Hot Water Fitters in formulating the 1912 schedule of standard weight and extra-heavy flanges and flanged fittings. This has been adopted by the Government in several of its departments and by numerous organizations.

As a result of interest awakened in the subject of measurement of taps, bolts and screws, a committee has been appointed to take up the matter, whose duty it shall be to prescribe the permissible tolerances in the commercial manufacture of these products, including their measurement.

The committee on Standard Cross-Sections and Symbols will report at the Annual Meeting on standards for drawings to indicate the materials used.

Upon invitation of the Patent Law Association, a conference was held in Washington at which the Society was represented, together with several other national societies. The Committee on Patent Law has been continued so that it may attend any conferences which may arise and participate in any developments, reporting to the Society as the necessity may arise.

At the Annual Meeting the very complete and remarkable report of the Committee on Power Tests will be presented and thus bring up to date and extend the present reports of the Society on these subjects.

REPORT OF FINANCE COMMITTEE

Appended will be found the certified report of the examination of the accounts of the Society, made by Messrs. Peirce, Struss & Company, for the fiscal year of the Society, ending September 30, 1912.

Your Finance Committee reports that the total income of the Society for the fiscal year ending September 30, 1912, was $112,-535.06, being an increase of $17,453.32 over the previous year. These increases are largely due to the very excellent work of th Increase of Membership Committee, the Sales Department and the Advertising Department.

The total expenditures of the Society were $101,306.25, an increase of $6,915.42.

Your Committee feels that it must not neglect to call attention to the great expenses charged to the account of the Membership Committee, which amounts to over $5 for each new member joining the Society. This expense all accrues after the application is received and includes the cost of the Certificate of Membership, about $1 apiece. Your Committee respectfully urges that the Membership Committee gives especial attention to this matter with a view to eliminating a large proportion of this expense.

The Publication Committee has spent but $44,516.40, out of an appropriation of $48,300, but there are some expenses, estimated to amount to $4200, in connection with Volume 33 of Transactions, which have already accrued but are not paid. The Finance Committee recommends that this amount be set aside from the income of the year ending September 30, 1912, for meeting this expense.

It is estimated that the income of the Society for the year ending September 30, 1913, will be $117,329, and your Finance Committee recommends the following appropriations, amounting to $106,775:

Finance Committee	$23,375
Membership Committee	2,500
Increase of Membership Committee	1,800
House Committee	2,000
Library Committee	4,500
Meetings Committee	5,500
Council	7,000
Publication Committee	50,500
Power Tests Committee	1,000
Research Committee	100
Society History Committee	500
Sales Expenditures	8,000
	$106,775

Your Committee would further advise that as the year progresses close watch be kept of the income and expenses and that if the income should increase or decrease the appropriations should be modified accordingly, being maintained in the aggregate at about 90 per cent of the expected income.

Respectfully submitted,

R. M. Dixon, *Chairman*
W. H. Marshall
H. L. Doherty,
W. L. Saunders
W. D. Sargent
Finance Committee

APPENDIX TO REPORT

November 1, 1912.

Mr. R. M. Dixon,
Chairman Finance Committee

Dear Sir:

In accordance with your instructions, we have audited the books and accounts of The American Society of Mechanical Engineers for the year ended September 30, 1912.

The results of this examination are presented in three exhibits, attached hereto, as follows:

Exhibit A Balance Sheet, September 30, 1912

Exhibit B Income and Expenses for the year ended September 30, 1912

Exhibit C Receipts and Disbursements for the year ended September 30, 1912

We beg to present, attached hereto, our Certificate to the aforesaid exhibits.

Peirce, Struss & Co.,
Certified Public Accountants

November 1, 1912

Mr. R. M. Dixon,
Chairman Finance Committee

Dear Sir:

Having audited the books and accounts of The American Society of Mechanical Engineers for the year ended September 30, 1912, we hereby certify that the accompanying Balance Sheet is a true exhibit of its financial condition as of September 30, 1912, and that the attached statements of Income and Expenses, and Cash Receipts and Disbursements are correct.

Peirce, Struss & Co.,
Certified Public Accountants

EXHIBIT A

Balance Sheet, September 30, 1912

ASSETS

Equity in Society's Building (25 to 33 West 39th Street)	$353,346.62	
Equity one-third cost of land (25 to 33 West 39th Street	180,000.00	
		$533,346.62
Library Books	13,000.00	
Furniture and Fixtures	5,000.00	
		18,000.00
New York State 3½% Bonds 1954 (Par $35,000.00)	30,925.00	
Cash in Banks representing Trust Funds	11,320.78	
		42,245.78
Stores including Plates and finished publications		13,076.70
Cash in Banks for general purposes	21,322.32	
Petty Cash on hand	350.00	
		21,672.32
Accounts Receivable		
Membership Dues	8,635.75	
Initiation Fees	1,155.00	
Sale of Publications, Advertising, etc	10,400.69	
		20,191.44
Bills receivable		612.45
Advance payments		1,675.54
Total Assets		$650,820.85

LIABILITIES

Certificates of Indebtedness		$74,800.00
Funds		
Life Membership Fund	$35,386.07	
Library Development Fund	4,902.71	
Weeks Legacy Fund	1,957.00	
		42,245.78
Dues paid in advance		1,559.13
Initiation Fees uncollected		1,155.00
Unappropriated Revenue		11,228.81
Reserve (Initiation Fees)		35,759.89
Surplus in Property and Accounts Receivable		484,072.24
Total Liabilities and Surplus		$650,820.85

EXHIBIT B

Income and Expenses for the Year Ended September 30, 1912

INCOME

Membership Dues	$61,198.01	
Sales, Gross Receipts	10,908.15	
Advertising	38,562.22	
Interest and Discount	1,866.68	
Miscellaneous	......	
Total		$112,535.06

EXPENSES

Finance Committee	$25,889.43	
Membership Committee	3,572.04	
Increase of Membership Committee	1,887.53	
House Committee	1,895.31	
Library Committee	4,521.64	
Meetings Committee	6,083.69	
Council Committee	4,438.09	
Publication Committee	44,516.40	
Research Committee	101.75	
Power Tests Committee	50.00	
Sales Expenditures	7,750.37	
Reserve Fund	600.00	
Total		$101,306.25
Excess of Income over Expenses		$11,228.81*

*$4200 of this amount was reserved to complete Trans., vol. 33.

EXHIBIT C

Receipts and Disbursements for Year Ended September 30, 1912

RECEIPTS

Membership Dues	$59,270.81	
Initiation Fees	10,270.00	
Membership Dues and Initiation Fees paid in advance	1,485.80	
Sales of publications, badges, advertising, etc.	48,155.94	
Subscription to Land Fund	344.00	
Interest	2,479.92	
Certificates of Indebtedness	35,149.04	
	$157,155.51	
Cash in Bank and on hand, September 30, 1911	31,081.10	
		$188,236.61

DISBURSEMENTS

Disbursements for general purposes	$114,243.51	
Cancellation of Mortgage	41,000.00	
Cash in Banks and on hand, September 30, 1912	32,993.10	
		$188,236.61

REPORT OF THE HOUSE COMMITTEE

The work of the House Committee during the past year has been generally confined to routine matters. No further material additions have been made to the decorations or furnishings of the rooms of the Society. Some improvements in ventilation of the rooms and offices have been effected and new equipment purchased to facilitate the business work of the Society. A number of additional portraits of honorary members have been secured and framed, and present prospects indicate the substantial completion of this collection in about two years' time.

Respectfully submitted,

Francis Blossom, *Chairman*
Edward Van Winkle
H. R. Cobleigh
S. D. Collett
W. N. Dickinson
House Committee

REPORT OF THE COMMITTEE ON MEETINGS

With reference to financial expenditures, reading and judging of papers, the number of meetings held, and similar routine matters, the work of the Committee on Meetings has been for the past year substantially on the same basis as for the preceding year. At no time in the year is any member of this committee free from Society service and the continuity of this demand cannot be realized by any one who has not served on it. Most of the work is conducted by correspondence, but in no case is any committee action taken without substantially unanimous approval. Through the winter months meetings are held weekly or bi-weekly, as the business demands, for the clearing up of matters that cannot be disposed of by correspondence and for verbal discussion on questions of policy.

The service that the Society demands of the Committee on Meetings is considerably more in quantity and quality than a single committee of five men can efficiently perform. It is this feeling that prompted the recommendations last year for the effective enlistment of the Society membership in assisting the work of the Committee on Meetings by organizing sub-committees. It is, therefore, with considerable satisfaction that your committee is able to report not only the inauguration of this plan but its successful operation. At the present time there are in existence ten sub-committees, each having accepted the duty

of advising the Society through its Committee on Meetings not only of topics which should be treated in these respective fields, but also securing the proper treatment in papers and discussion. These committees comprise Textiles, Administration, Cement Manufacture, Iron and Steel, Industrial Building, Hoisting and Conveying, Railroads, Machine Shop Practice, Air Machinery, and Fire Protection. This plan should be continued until every branch of professional interest and public service shall be represented by a sub-committee that can give it whatever public expression it merits.

In the conduct of the two stated meetings of the Society, the Committee on Meetings is also enlisting the services of other sub-committees to take charge of the social and entertainment features, duties which, while only intermittent, involve very considerable labor and time. This year these features of the Annual Meeting are divided between the House Committee, which will take charge of all the details of the President's Reception, and the New York Local Committee, which will have the care of all other social sessions. In connection with the latter, your committee also reports the inauguration of the policy of payment for the social entertainment by those participating, all funds for this purpose being derived from the sale of tickets. It is hoped that this plan will work so successfully at this year's Annual Meeting, where it will have its first trial, that it can be likewise applied to the Spring Meeting, relieving local membership in various cities of the necessity of personal contributions for the entertainment of others.

Respectfully submitted,

Charles E. Lucke, *Chairman*
H. deB. Parsons
W. E. Hall
H. E. Longwell
H. L. Gantt

Committee on Meetings

REPORT OF THE COMMITTEE ON MEMBERSHIP

During the past year the Committee on Membership has held ten meetings for the transaction of its work, and in addition three joint meetings with the Committee on Increase of Membership. The number of applications acted upon is as follows:

Applications pending October 1, 1911	94
Applications received during fiscal year October 1, 1911 to September 30, 1912	771
	865

On these applications the following action was taken:

Recommended for membership	694
Withdrawn for various reasons	4
Deferred indefinitely	4
Deferred for further information	3
Applications held pending the receipt of endorsement of required number of references which did not arrive up to the date of closing	160
	865

It was also voted to reinstate eight members.

This committee, after extended investigation, recommends an additional grade of membership, with consequent modifications of the Constitution, to be voted upon at the Annual Meeting; and has also revised both membership applications and endorsement blanks with a view to omitting certain features which have been criticized, and simplifying the former to facilitate and reduce the cost of handling. The following comparison shows that some reduction in cost has already been secured:

In 1911, 368 candidates were placed on the Professional Service Sheets, at a cost to the Society of $5.81 each for the clerical work of the committee and for the ballot by the entire membership. In 1912, 694 candidates appeared on the Professional Service Sheets at a cost of $5.14 each.

Of the total expenditures ($3572.04) chargeable to this committee during the past year, $1925.15, or approximately 54 per cent of the total, was incurred for the printing, mailing and handling of the Professional Service Sheets and Ballots, which amount will be wholly saved under the new system of election and announcement now under consideration.

A further possible economy not yet fully investigated but perhaps worthy of consideration, may be effected by making a charge to new members for the certificates of membership now furnished free of charge. A preliminary search shows that the principal European scientific societies furnish their certificates without charge. Of the American Societies, the American Institute of Mining Engineers do not issue a certificate, the American Institute of Electrical Engineers charge $1 for a member-

ship certificate, and the American Society of Civil Engineers furnish a paper certificate free of charge, but charge $2 for a parchment certificate.

Although the annual gain in members has been increased 88½ per cent over last year, a perusal of the last two ballots is most gratifying and convincing proof that the standard of membership has been fully maintained and will in no way be lowered by a dignified presentation to the mechanical engineering profession of this country of our claims to their membership and support, and the benefit to be derived by them from the constantly increasing lines of investigation and discussion in every branch of mechanical engineering presented at the meetings, and through The Journal of the Society.

Respectfully submitted,

G. J. Foran, *Chairman*
Hosea Webster
Theo. Stebbins
W. H. Boehm
H. C. Meyer, Jr.
Committee on Membership

REPORT OF COMMITTEE ON PUBLIC RELATIONS

The Committee on Public Relations having been requested by one of our Philadelphia members that the Society coöperate in matters of public interest, responded by notifying the local members in their individual capacity. While the Society, as such, may not always respond exactly as invited, it may in effect assist in relations of the engineer with the public, by corresponding with the members individually, inviting their attention to certain matters, and thus perform our duties in this regard.

Your committee would be pleased to receive communications and will do their best on all occasions to develop this activity of the Society's work.

Respectfully submitted,

James M. Dodge, *Chairman*
D. C. Jackson
John W. Lieb, Jr.
Fred J. Miller
Worcester R. Warner
Committee on Public Relations

REPORT OF THE PUBLICATION COMMITTEE

The adequate presentation and record of the growing work of the Society has imposed upon the Publication Committee an increasingly difficult task. It is impossible to present in a single volume of Transactions all of the papers presented before the Society at its two regular meetings and at the meetings of the several local groups and selections, as well as the record of Council and Committee meetings, administrative affairs, etc.

At the commencement of its term this committee decided with the approval of the Council, to confine the papers recorded in the Transactions to those presented at the regular spring and fall meetings, with a condensation of the discussion thereon, bringing within this category papers of exceptional merit presented at local or section meetings by referring them to the Committee on Meetings, with a recommendation that they be presented, at least by title, at one of the regular meetings; and further, that matter of administrative and only temporary interest would find sufficient publicity in The Journal and might be omitted from Transactions.

During the past year the number of papers presented at the regular meetings has been such that even with the discussion evoked condensed to the utmost, it is impossible to print them in a volume of less than 1500 or 1600 pages. The cost of such a volume would be $10,000, or $2000 in excess of the appropriation available for this purpose.

The committee requires an expression from the Council as to whether it may have the additional appropriation of $2000 necessary to print a volume which shall include all of the papers presented at the spring and fall meetings with the condensed discussion thereon.

There has been no general index of Transactions published previous to Volume 20. An appropriation of $1000 is now available for the purpose of bringing this index up to date, and steps will be taken to put the work immediately in progress.

The progress of The Journal has been most gratifying. It is the purpose of its editor, heartily concurred in by the Committee, to make it not only a means of communication between the membership and headquarters, and of distributing the papers presented before and the record of work accomplished by the Society itself, but an epitome of progress in the world

of mechanical engineering indispensable to any active member of the profession. The Foreign Review, instituted during the past year is a step in this direction. It is hoped to extend this and kindred features until the contents of The Journal shall include at least directions to information upon everything of importance developed or presented in its field.

During the past year The Journal has earned $2000 over its expenses, taking care of the publication work incidental to (*a*) the increase of material presented at the various meetings, due to the formation of local committees and subcommittees, and (*b*) the increase in membership which includes the addition of over 1000 student members and affiliates since The Journal began to publish advertising, and (*c*) the Foreign Review which involves an expenditure of about $4000 per year. The present edition is 6500 with an average of 190 pages per month, as against an edition in 1907-1908 of 4000 with an average of 140 pages.

For the first time in the history of The Journal we have published some account of the papers and discussion at all meetings in which the Society participated, and synopses of the papers and discussion presented at all meetings held under the supervision of the Society whether locally or otherwise. The cost per 100 pages per 1000 copies has diminished from $135 at the time advertising was started to $120. The condensed catalogue plan of advertising has proved attractive and is more in keeping with the character of the Society's publication than the usual display advertising.

The Journal has proven its potency to serve the Society in many ways, with no draft upon the Society's funds, and is capable of being made a source of considerable revenue or of supporting itself in a wider field of activity and usefulness. By the publication of papers, committee reports, etc., in The Journal, the Society is now saved what was formerly a considerable item of expense for printing and distribution.

The Society must soon consider whether in view of the opportunities for publicity and record afforded by The Journal it desires to continue the publication of Transactions. At the present rate of increase it will soon be necessary to print two volumes per year. This will mean an annual expense of from $13,000 to $16,000. The two publications involve a duplication of expense and effort in many ways, and it is possible that a plan might be evolved whereby the binding of The Journal in whole

or in part might serve all the purposes of Transactions with a considerable saving.

Respectfully submitted,

F. R. Low, *Chairman*
G. I. Rockwood
G. M. Basford
C. I. Earll
I. E. Moultrop
} *Publication Committee*

REPORT OF RESEARCH COMMITTEE

Although the activities of the Research Committee have shown a decided increase during the year, it is still evident that the membership of the Society does not realize the existence of the committee and the power which it can exert for stimulating research in many directions, tending to advance the cause of mechanical engineering. The committee should be the medium by which the members of the Society bring to bear upon their problems the best assistance of the members of the profession throughout the country, and it is hoped that a greater realization of the possibilities of the committee in giving such assistance may be attained.

The committee has felt that the best way to bring these possibilities to the attention of the membership was to secure, first, statements from experts in the form of papers, abstracts, etc., of the present state of knowledge in various directions; and, second, to use these papers in the widest possible way to stimulate research to extend such knowledge. With this in view, the sub-committee on Steam Research secured a paper last year from Mr. George A. Orrok, on the Transmission of Heat through Metallic Tubes, an extremely able resumé of the present state of knowledge in that field; and has this year secured from the same author a continuation of this paper in the form of a digest of the technical literature on the transmission of heat. While this digest is not proper material for a paper to be presented before the Society, it is of the greatest value and the committee recommends that this paper be printed and thereby placed at the disposal of the members of the Society.

In addition the following papers on the following subjects are in preparation: The present status of the railroad rail question, with reference to the increased service demanded of rails and the improvements being made in rail construction,

forming in fact a complete resumé of the entire question of breakage of railway rails and the steps being taken to relieve this condition in the future; deterioration or growth of cast iron in an atmosphere of superheated steam; the effect of pulsating flow on the accuracy of flow meters; steam heating of towns from central stations; amount of air and other gases in injection water.

There has been considerable discussion on plans for future activities, which will no doubt bear fruit in the succeeding year.

Research work is in progress on the coefficients of elasticity of ceramic materials, at the instigation of the committee on Mechanical Properties of Materials used in Electrical Engineering.

The following sub-committees have been appointed and have shown activity and devotion to the subjects assigned to them: Sub-Committee on Steam Research: L. S. Marks, C. J. Bacon, E. J. Berg, W. D. Ennis, J. F. M. Patitz, R. H. Rice; Sub-Committee on Research in Materials of Electrical Engineering: R. D. Mershon; Sub-Committee on Research in Safety Valves: P. G. Darling, E. F. Miller, H. D. Gordon, F. L. Pryor, F. M. Whyte.

Respectfully submitted,

Richard H. Rice, *Chairman*
R. D. Mershon
W. F. M. Goss
A. L. DeLeeuw
R. C. Carpenter

Research Committee

NECROLOGY

MAUNSEL WHITE

Maunsel White, for many years Engineer of Tests and Metallurgist of the Bethlehem Iron and Steel Works, died in New Orleans on October 22, 1912. He was born in Plaquemines parish, La., on March 15, 1856, of a prominent southern family. After a few years of study under private tutors and in Georgetown University, near Washington, D. C., he entered the school of technology at Worcester, Mass., and later the workshops of the Lehigh Valley Railroad at Weatherly, Pa. Here he gained a practical knowledge of mechanics which determined him to secure an engineering education. In 1875, accordingly, he became a student at Stevens Institute of Technology, from which he was graduated four years later as valedictorian of his class.

Immediately afterward, White was engaged by the Bethlehem Iron Company, under John Fritz, then largely manufacturing merchant steel and rails, now the Bethlehem Steel Company, and later became chief of the metallurgical department, taking high rank as an authority upon metals. He represented his company and was in charge of their exhibit at the World's Fair in Chicago in 1893, as well as at the Paris Exhibition of 1900, receiving personally at the latter a bronze medal of merit as a result of his company's exhibit; and he made frequent visits to Europe in the same capacity during his connection with the company, arranging among other things for the sale of great quantities of armor plate to the government of Russia, through personal interviews with the ministers of the Czar and at least one audience with the Czar himself.

Both the chemistry of iron and steel and the physical properties of these metals have been so thoroughly studied during the past 30 years and practice concerning them has become so crystallized, that the engineer of today finds it difficult to appreciate that facts which now seem elementary and commonplace were unknown in the early days of the industry. The life of the metallurgist in those days was intense and exciting. Problems

were crowded on him upon which depended the very life and existence of his company, and in the solution of these problems, in wringing these secrets from nature, Maunsel White had a large though often inconspicuous part. The confidence inspired by his work is shown in the trust placed in him by the government officials detailed to supervise the manufacture of armor plate and ordnance at the time the Bethlehem Steel Company was so largely engaged in its construction. White's O.K. on a piece of steel was regarded as final.

Maunsel White will best be remembered through his part in the extended investigation which led to the discovery of the Taylor-White process of treating steel and the development of "high-speed" tools, which have revolutionized the machine shop practice of the world. In general he has been accorded the credit which belongs to him in the discovery of this process, but few have appreciated the detailed thoroughness of his work, that true scientific devotion which enabled him to plod along, month after month, developing methodically one fact after another, and the rare ability with which he was able, in the end, to coördinate and group these facts so as to indicate the conclusions and theories towards which they tended. High-speed tools have in many cases doubled and trebled the output of metal-cutting machines, and practically all makers of high-speed steel have today adopted for their best brand, steel of almost the exact chemical composition recommended by White as a result of his experiments.

While Maunsel White will ever be remembered for his metallurgical discoveries, his friends knew him as a man of rare versatility and catholicity of taste, with an intense love of literature and the arts and marked ability in these directions as well as in the realm of applied science. He was both a poet and a mathematician, a combination in the same individual so rare that in this respect he was a marvel to all his friends. Alive to beauty, he could at the same time get at the kernel of a problem with quickness, clearness and accuracy. His work at the Bethlehem Steel Company gained for him the friendship and admiration of John Fritz, the dean of the steel industry in America.

Mr. White was widely known both in America and abroad, and was a member of the Iron and Steel Institute of Great Britain and the American Institute of Mining Engineers.

PRELIMINARY REPORT OF THE COMMITTEE ON STANDARD SIZES OF CATALOGUES

The Committee has made an extensive investigation of the various sizes of catalogues in common use, and has had correspondence with many paper manufacturers, printers, advertising agents and makers of filing boxes and cabinets, as well as with manufacturers of machinery and supplies. The general conclusions it has reached may be summarized as follows:

a There is a universal opinion that catalogue sizes should be standardized. It is not necessary to give any reasons here for this opinion, as it is all on one side.

b The standard of 6 by 9 in. has for so many years met with such wide acceptance, probably two-thirds of all the catalogues that are now made being either that size, trimmed as closely to exact size as possible, or within $\frac{1}{4}$ in. of it in one or both dimensions, that it may be considered as too well established ever to be abolished.

c The 6 by 9 size is too small for many purposes, and it is necessary to have for some purposes a size which is about 8 by $10\frac{1}{2}$ in. or $8\frac{1}{2}$ by 11 in.

d Large manufacturing concerns have spent a great deal of money in having cuts and electrotypes made for these two large sizes, some using one size and some the other so that it is not to be expected that either size can be abolished. There is no serious objection to having both sizes remain as acceptable standards. Both of them are in use as standard sizes of letter paper, and both may be conveniently filed in the same filing case.

e The 9 by 12 in. size has been adopted by a few for very large catalogues. While it is generally acceptable for technical and trade journals, it is rather too large for a catalogue, unless it is to be a large

cloth-bound book, to be placed on a shelf and not filed in a cabinet. It should, therefore, not be recommended as a standard for common use.

The following extracts from some of the letters received show the variety of opinions that exist as regards the sizes that should be adopted:

Matthews-Northrup Works, Buffalo, N. Y. Paper stock is made in sheet sizes 25 by 38 in. Since cuts have been made and tabular pages set for years to fit 6 by 9 in. it should prove very expensive for many firms to change. An opportunity is afforded by the 9 by 12 in. size to run the text descriptive matter or tabular panel of sizes and prices immediately under the illustrations on the same page. The 8½ by 11 size works out in good proportions. These three sizes seem to be the only ones that need be planned for.

Robert L. Stillman, New York. I suppose there are more catalogues made 6⅛ by 9¼ or 9⅜ by 12¼ than any other size, because they both cut from 25 by 38 in. paper which is of standard size, allowing ⅛ in. for trim.

The 33 by 46 in. size would make 8⅛ by 11¼. It might be reduced to 11 in. to get it within the standard letter size.

Ticonderoga Pulp & Paper Co., New York. It would be much to the advantage of every one if all catalogues could be standardized to a certain size. It would be a great assistance not only to the paper manufacturer but also to the dealer and printer, as in that case the dealer could carry in stock standard sizes and could supply paper promptly, and printers would not then have to wait for paper to be made especially.

Frank Presbrey Co., New York. Sent samples 6¾ by 9¾, and recommended it as the size used in all standard magazines. In reference to letter size, 8½ by 11, if a movement be inaugurated which will result in making up to this size all catalogues and monthly bulletins a great deal will be accomplished.

Collin Armstrong Advertising Co., New York. As far as our experience goes 5½ by 8 in. is the most convenient size. Anything near 8½ by 11 would in our opinion be too large to be handled easily, would be apt to go to pieces quickly and probably not be kept carefully by the recipient, as would be the case with a smaller book.

F. F. Coleman, Publicity Manager, Lidgerwood Mfg. Co., New York. All publications except catalogues intended for filing should be eliminated from consideration. The best size for catalogues is 9 by 12 in. upright. Personally, I would abolish the 6 by 9 size.

J. Horace McFarland, Harrisburg, Pa. In the nursery trade the 6 by 9 size does not permit such attractive illustrations in an economical manner as the growing vigor of selling campaigns required, and there is a great disposition to get away from anything of a standard size and to make the catalogue different.

Hammacher, Schlemmer & Co., New York. Are working on a new edition of their catalogue which will be 9 by 12 in. For a number of years

they used 5½ by 7¾, but it is too small for a book of say 1200 pages. For pamphlets and smaller sizes will use 6 by 9 in.

Manning, Maxwell & Moore, New York. Books for general mechanical goods, both small and large should be 6 by 9 in. wherever it is practicable. In many cases a larger sheet is necessary to take the proper size cut to show important small details.

General Electric Company, Schenectady, N. Y. We use and recommend 8 by 10½ in. catalogues as standard. The width of page is valuable for displaying illustrations and tabular matter. Our standard letter paper is 8 by 10½ in. Or standard photographic plate is 8 by 10 in.

The Yale & Towne Mfg. Co., New York. C. L. Redfield, Adv. Mgr. Printed matter may well be any of the following sizes for reasons given: 6 by 3⅜ in. for folders, because this size just fits the small Government envelope which is still very largely in use among business people; 8 by 3½ in. for folders and small booklets, because it just fits the No. 9 Government 2 cent envelope and makes it very easy to use such printed matter to accompany correspondence; 6 by 9 in. for small catalogues, as we have been led to believe that this is more acceptable to the machinery and other trades; 8 by 10½ in. for sheets which accompany correspondence, as this is the size of our letter head; 9 by 12 in. for our more important catalogues, this being the accepted size with the paper makers and is carried in stock.

RECOMMENDED SIZES

	In.
Index Card, Standard	3x5
Index Card, Larger Sizes	4x6 and 5x8
Folders, Small 6x3⅜	Large, 8x3½
Catalogue, Standard Size	6x9
Bulletins and Large Catalogues, Standard	8x10½ and 8½x11
Bulletins and Large Catalogues Smaller than Standard	8x10½

In addition to the recommendation as to sizes the Committee would also recommend the following:

a For paper covered catalogues intended to be permanently filed, the edges, including the cover, should be trimmed to exact size. No fancy deckled edge or dark tinted paper should be used.

b Overlapping edges of the cover are permitted when the catalogue is bound in covers stiff enough to support its weight in boards or heavy card paper.

c The title should always be printed on the exposed back of the catalogue, even in very thin stitched books, for the purposes of identification.

d Every catalogue should have a date on its title page.

e A standard size index card 3 by 5 in. should be enclosed in each catalogue, with the title of the book and a brief statement of the character of its contents printed on it.

Catalogues, Extra Large, and Technical Press......9x12

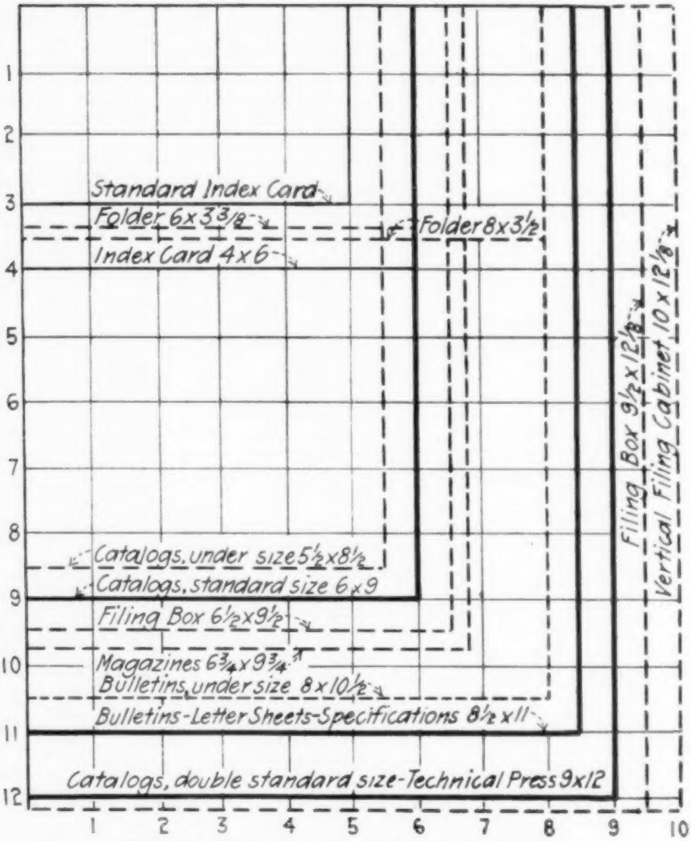


FIG. 1 RELATION OF CATALOGUE SIZES

Transactions of Societies, Pamphlets, etc............6x9

PAPER BOXES, DRAWERS AND VERTICAL FILING CABINETS

(Inside Measurements)

For 6 x 9 in. catalogues, pamphlets and 9 x 12 papers folded once....................6½ x 9¾

Paper Boxes and Drawers for larger sizes....9½ x 12⅛

Vertical Files for large sizes................ **10 x 12⅛**

Fig. 1 which gives a clear idea of the relation of these several sizes to each other is drawn to scale, showing them superposed.

FILING BOXES AND CABINETS

Jesse Jones Paper Box Co., Philadelphia, Pa.

A box that will hold a sheet 8½ by 11 in. is by far the most in demand.

Various makers of filing cabinets give the following sizes of drawers (inside measurements):

Correspondence Files 9⅞ x 11 9/16, 10 x 12, 10½ x 12⅛, 10 7/16 x 12.
Legal cap Files, 9⅞ x 14⅜, 9½ x 15, 10½ x 15¼.
Invoice Files, 7½ x 9½, 7¾ x 9¾, 8 x 10, 8¼ x 10 1/16.

The 9⅞ x 11 9/16 is too short to take a 9 x 12 in. paper. There seems to be no reason for making the height more than 10 in. as no letter paper is over 8½ in. wide. A size of 10 in. high by 12⅛ in. wide would seem to be the best for all large size catalogues. It would hold two 6 x 9 in. side by side, although the filing of 6 x 9 and 9 x 12 in. papers, together in the same drawer is objectionable, as the smaller sized papers have a tendency to lap over on each other and thus to occupy more space than they should. The extra inch in height gives ample room for division cards and tabs. The legal cap and the invoice files are not suitable for any of the standard sizes of catalogues. A size suitable for the 6 by 9 in. catalogue does not appear to be in the market. If one were made with drawers about 6½ by 9¾ in. it should have a ready sale. The drawer would be more easily handled than the 10 by 12⅛ in. size.

In submitting the above preliminary report the Committee desires to receive, from members of the Society and others interested in the subject, written discussions and criticisms of the recommendations. It is requested that if changes are suggested they be worded so that they may be inserted without modification in the revised report. When the preliminary report has been fully discussed and criticised the Committee will make a final revision for publication in the Transactions.

Respectfully submitted,

WM. KENT, *Chairman*	*Committee*
J. R. BIBBINS	*on Standardization*
M. L. COOKE	*of Catalogues*
W. B. SNOW	

REPORT OF THE COMMITTEE ON STANDARD CROSS-SECTIONS AND SYMBOLS

We, the undersigned committee appointed by the President under the direction of the Council, to take up the matter of cross-sections and symbols, as suggested in a paper presented at the annual meeting of the Society in December 1911, beg leave to report that we have held meetings, have also carried on our work by correspondence, and now convey our unanimous findings as below:

We strongly believe that there should be recognition of a standard method of showing materials in cross-section. There are many advantages in encouraging the use of standard cross-sections and symbols. It is as easy to draw an adapted design to represent a specific material as to draw any other. It makes mechanical drawings easier to read and understand, and diminishes the danger of interpreting their meaning wrongly.

We do not believe it wise to complicate the matter by adopting too many standard cross-sectionings or symbols. We believe that it would be best to have standard cross-sections for the most commonly used materials, and that these should be of such a character as to permit of subdivision, if found desirable.

To this end, we propose the use of standard cross-sections to represent nineteen materials as shown on Fig. 1, viz., cast-iron, wrought-iron, cast-steel, wrought-steel, babbitt (or white metal), copper (brass or composition), aluminum, rubber (vulcanite or insulation), glass, wood, water, puddle, concrete, brick, rubble, ashlar, rock, earth and sand. To facilitate the drawing of cross-sections, the committee have used the same thickness for all lines made with the drawing pen.

On some drawings it may be desired to specify a material other than those mentioned above, or some particular kind of material which the above generic names would not clearly indicate. To cover this contingency, we recommend writing the name of

such material on the section and cross-hatching the section, as shown on Fig. 1 under the title Other Materials.

We recommend that subdivisions of any of the materials shown

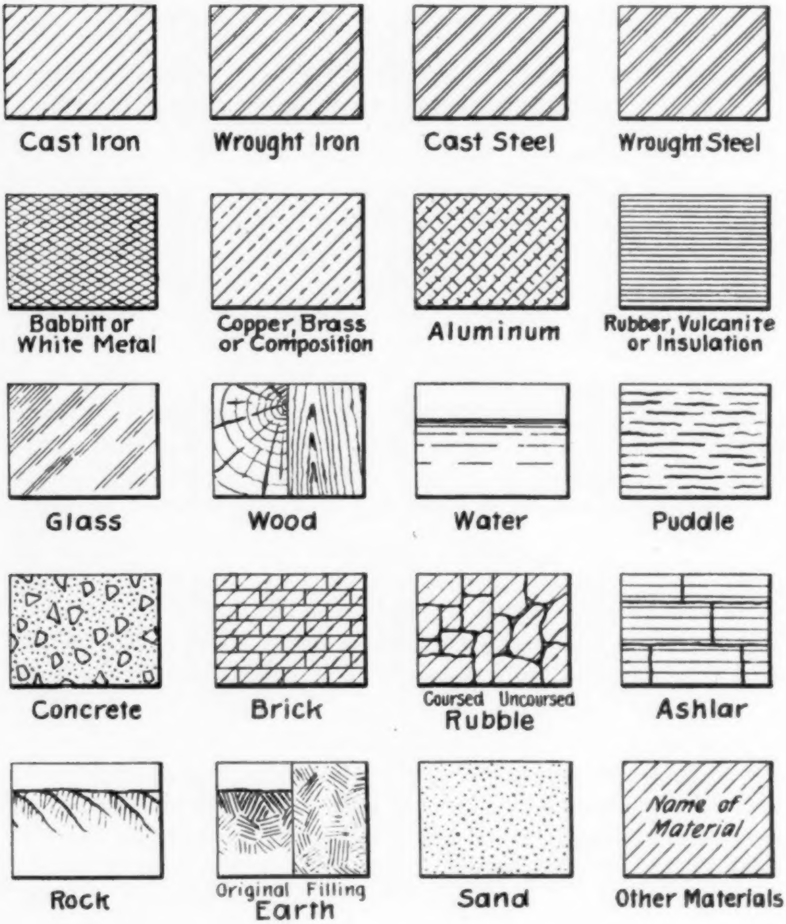


Fig. 1 Recommended Standard Cross-Sections

generically on Fig. 1, should be made by taking one of these standard cross-sections as a basis and making minor changes, but maintaining the general characteristics; or by writing on the standard section the name of the material. To illustrate, the

committee have subdivided concrete into concrete-blocks, cyclopean-concrete and reinforced-concrete, as shown on Fig. 2, and also wrought-steel into nickel, chrome and vanadium steels.

We urge the Society to adopt standard cross-sections. Such standard cross-sections should be printed in a suitable form for hanging on walls of drafting rooms of engineers, architects, and educational institutions, so as to encourage their universal use.

Before closing, we acknowledge the valued assistance of Mr.

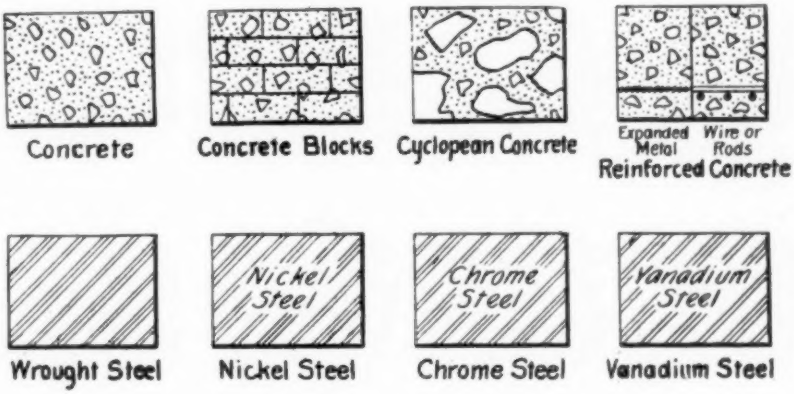


Fig. 2 Typical Subdivisions

D. C. Johnson in obtaining data for the committee and extend our thanks to the many manufacturing establishments, government departments and individuals who have sent us such standards as are in use by them.

Respectfully submitted,

H. de B. Parsons, *Chairman*
F. DeR. Furman
A. E. Norton
Bradley Stoughton
John W. Upp

Committee on Cross-Section and Symbols

NECROLOGY

ALBERT W. DANFORTH

Albert W. Danforth who died at his home in Lowell, Mass., on April 25, 1912, was educated in the Lowell public schools and began his professional career as mechanical engineer for the Lawrence Corporation of that city. A few years later he became mill and constructing engineer for the Hamilton Corporation, and subsequently designer and superintendent of construction on machinery for the United States Cartridge Company, and mill and mechanical engineer in Newburyport. In 1882 he went to China in the employ of the Chinese Government to build a cotton mill at Shanghai, owned by Li Hung Chang, then viceroy of the province, remaining there for twenty years and doing much to introduce European methods of cotton manufacture into the country.

SAMUEL TENNEY MUDGE

Samuel Tenney Mudge died at his home in South Manchester, Conn., on September 8, 1912. Mr. Mudge was born in Brooklyn, N. Y., on February 22, 1883, and received his education at the Stevens Institute of Technology, from which he was graduated with the degree of M.E. in 1906. He entered the service of the American Sugar Refining Company in Jersey City in the same year, and two years later became instructor in machine design in the University of Michigan. At the time of his death he was general manager and superintendent of the mills of the Rogers Paper Manufacturing Company, South Manchester, Conn.

J. M. ROBINSON

J. M. Robinson, president of the Crex Carpet Company of New York, who died on March 30, 1912, was born in New York on July 19, 1849, and educated in the public schools. He received his engineering training in Cooper Institute and through practical experience.

Mr. Robinson had charge for some time of the linesmen and building of the Western Union Telegraph Company, and was

associated with the Mills Estate, erecting the Mills Buildings in New York and San Francisco, and having active management of the property. He was also interested in many commercial enterprises, including the company of which he was president at the time of his death.

Mr. Robinson was a resident of Teaneck, N. J., and actively interested in the Board of Education and in political and social affairs of that township.

AMORY E. ROWLAND

Amory E. Rowland was born July 2, 1852, in Brooklyn, N. Y., and educated in the Sheffield Scientific School of Yale University. He gained experience after graduation in practical mechanics in the Continental Iron Works in Brooklyn and had been connected with the firm of F. C. & A. E. Rowland in New Haven and its successor, the Rowland Machine Company, about thirty-five years. At the time of his death on May 7, 1912, he was secretary and treasurer of the company.

Mr. Rowland was a trustee of the New Haven Savings Bank, director and prominently identified with the New Haven Colony Historical Society, the Graduates Club of New Haven, the Organized Charities Association, and other similar organizations.

JAMES B. SINER

James B. Siner, a mill engineer of Boston, died on September 17, 1912, at his home in Malden. Mr. Siner who was born in Lowell, Mass., on April 3, 1835, was educated in the public schools of that city and served his apprenticeship in the Lawrence Machine Shop. He began his career as mechanical superintendent of the Washington Mills at Lawrence, with which he was associated for twenty-two years, and was at the time of his death in charge of the appraisal department of the Factory Mutual Fire Insurance Company of Boston.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society, with names of other good men not members, and are on file in the Society office. Information will be sent upon application

POSITIONS AVAILABLE

0210 Assistant engineer, permanent position; must be experienced designer of electric traveling cranes, accurate and quick at figures, capable of systematizing engineering data. References as to experience and personal habits. State technical training and salary desired.

0211 Competent instructor in experimental mechanical engineering in one of the prominent state universities. Candidates for this position should have had successful teaching experience and some practical work. Salary available $1500 a year, with excellent prospects for advancement.

0212 Boiler shop superintendent or foreman to take charge of contract shop with blast furnace, smoke stack, tank and miscellaneous work. Live progressive man, but preferably with technical training, though not necessarily.

0213 Jig designer for New Jersey concern.

0214 Man to take charge of mechanical work of new plant, general millwright repairs, installation of additional machinery, repairs to motors and electrical machinery and the installation of new machinery; would have charge of small force of electricians and machinists, lay out work and keep up repairs in good shape.

0215 Leading draftsman on electrical work for prominent concern; conversant with power and substation equipment and capable of working up general plans and details of such work. Man of intelligence and initiative.

0216 Electrical engineer to act as associate to engineer in charge of electrical division of prominent Massachusetts concern; well grounded in theory and construction of such electrical apparatus as enters into station equipment and able to work out general problems connected with the extension of a plant, to make estimates, specifications, etc.

0217 Designer for rolling mill installations and similar types of heavy machinery. Must be a technical graduate. Salary $175 to $225.

0218 Opening in engineering department for a technical graduate of concern manufacturing ball bearings. Would want a man who would

begin as draftsman and work up to an engineer's position. Location Connecticut.

0219 Concern in New York State desires services of man for the purpose of investigating the electrical power propositions of the company, especially as applied to low-pressure steam turbines driven from mill engine exhaust. Applicant would have to be experienced along this line of work and able to take up the entire question.

0220 Shop superintendent for large plant, manufacturing line of small specialties, located in New Jersey, about 20 miles from New York. Position will require a technical graduate having considerable experience particularly in the manufacture of articles requiring interchangeable parts, automatic machinery, etc.

0221 Designer to work out new design of jig or develop present design.

0222 Man with stationary or marine engineering experience, familiar with the combustion of oil and the analysis and control of the gases of combustion by means of the Orsat apparatus, pyrometers, etc. Location small New Jersey town, about 30 to 35 miles from New York City.

MEN AVAILABLE

518 Junior, mechanical engineer, Cornell, age 27, married, desires position of some responsibility in inspection or production department of progressive manufacturing concern; experience in foundry of prominent pump manufacturer; cost department of a recognized maker of machine tools; tool room of large experimental machine shop; now employed as foreman of automobile assembly. Satisfactory references as to character and ability.

519 Member, M.I.T. graduate, married, desires position as plant ingineer, purchasing agent or superintendent of construction; 20 years' experience in estimates, valuations, purchases, designs, specifications construction, equipment testing and general operation of steam and hydraulic electric power plants, factories, textile mills and electric transmission of power. Salary $3600 to $4000.

520 Associate, age 35, desires position of responsibility in or near Philadelphia. Sixteen years' experience in civil, structural and mechanical lines, as draftsman, squad foreman, chief draftsman and checker at rolling, steel and pipe mills, blast furnaces, steel cars and locomotives, byproduct coke ovens and on chemical apparatus.

521 Technical graduate with degrees of M.E. and C.E., instructor for a number of years in machine design and descriptive geometry, wishes to take charge of machine design or descriptive geometry departments of a university or technical school. Author of recent text books on above subjects. Would accept position as mechanical or research engineer in manufacturing plant, consulting and testing work. At present employed but desires to change.

522 Recent graduate desires position as assistant to a superintendent or production engineer.

523 Member desires position as works manager, preferably with new

company just starting business; long experience as factory man and engineer; at present head of engineering department of large company.

524 Member, technical graduate, scientific training with thorough knowledge of chemistry and chemical processes, 9 years' experience in design and operation of steam and gas power installations and apparatus, specializing in the economic combustion and gasification of fuels, desires position with manufacturer; salary $3000; or will consider a position with consulting engineer on a salary partnership basis.

525 Mechanical engineer, thirty, desires responsible position with growing concern; nine years' experience in engine and boiler manufacture and general plate steel construction, in sales and engineering departments and as assistant manager; ability and initiative, good organizer. Graduate of leading engineering college. Eastern location desired, preferably Philadelphia, New York or Baltimore.

526 Member, at present at head of department of mechanical engineering of Eastern college, with thirteen years' successful experience as engineer of tests, mechanical engineer and superintendent of engine works, would like to become identified with firm of consulting engineers, or sales engineer with a manufacturing organization.

527 Sales manager, man of executive business capacity, 35 years of age, desires position. Technical education, manufacturing experience in foundry and machine shops, business experience, office and road.

528 Cornell graduate experience in hydroelectric, power plant and transmission line work.

529 Mechanical engineer, member, university graduate, 35 years' experience in the building, erection and managing of sugar and chemical plants, designing and building special apparatus, vacuum and condensing plants, power plants, etc., will consider position as superintendent, managing engineer of industrial plants, or take charge of branch office for the equipment of such plants.

530 Member, age 35, M.I.T. graduate, wishes to change. Fifteen years' experience in mechanical and civil engineering, including designing, erection, testing and operation and teaching engineering, five years in executive positions. Position as assistant to works manager of large plant or group of plants, or with consulting engineer. Minimum salary, $3000.

531 Manager or superintendent; mechanical engineer with practical shop, technical and commercial experience, expert in up-to-date manufacture of interchangeable parts, resourceful in design and process for reducing costs and increasing production, good organizer and production engineer with excellent executive ability. A-1 references.

532 M.I.T. graduate in mechanical engineering, age 25, has been employed as assistant to chief engineer in automobile plant. Desires position with concern having opportunity for such man, and where merit is determined by results.

533 Cornell graduate with several years' practical, mechanical, electrical and industrial engineering experience wants permanent position

with established company, with whom energy, perseverance and knowledge of up-to-date modern methods can be made of value. Thoroughly versed in design, development and building of special machinery and the management of men. Salary to be adjusted with value of services rendered.

534 Executive engineer $6,000 man open for position. Broad experience in design construction and operation of hydraulic, gas and steam power and manufacturing plants. Competent organizer and handler of men and machinery.

535 Junior member, three years' experience in selling, manufacturing and drafting. At present employed, desires position with manufacturing concern.

536 Graduate Massachusetts Institute of Technology, age 37, married, ten years' experience in pipe bending and coiling, also experience in feedwater heater and condenser design and in economical use of steam in manufacturing processes. Designing and selling automobile radiators and sheet metal parts.

537 Member, technical and practical mechanic, good executive with 12 years' experience as superintendent and manager; thoroughly posted on modern machine shop and foundry practice, desires position with live company. Experienced in steam engines, boilers, gas and gasolene engines, transmission and mill machinery.

ACCESSIONS TO THE LIBRARY

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This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

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Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C. Humphreys	J. H. Vander Veer	J. Strauss
Univ. of Arkansas	Apr. 12, 1910	B. N. Wilson	J. A. Dickinson	W. B. Gardner
Univ. of California	Feb. 13, 1912	Joseph N. Le Conte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. F. Lytle	A. O. Hurxthal
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	L. G. Smith	C. A. Schoessel
University of Kansas	Mar. 9, 1909	P. F. Walker	E. A. VanHouten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	F. I. Kemp	R. Runge
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	P. S. Toney	M. C. Evans
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. D. Moyer	W. K. Fitch
Washington University	Mar. 10, 1911	E. L. Ohle	E. Dougherty	E. L. Lacey
Yale University	Oct. 11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER

By Calvin H. Crouch

ABSTRACT OF PAPER

The North Dakota lignite fields cover approximately one-half of the State, or about 35,000 square miles. According to the State Geological Survey report, there were known to be in 1908 twenty-one workable seams of this coal in the southwestern part of the State, varying from 4 to 35 ft. in thickness and found in from 1000 to 1300 ft. of strata.

In this paper are reported some preliminary experiments showing the physical properties of the coal and the results when subjected to heat and the drying action of air; also two evaporative tests and 18 gas producer power plant tests, in which the coal was used as it came from the mine, except that it was broken so as to be charged easily into the gas producer.

The results of the evaporative tests, though not as satisfactory as could be desired, were interesting and instructive, indicating the possibilities of its use for such purposes and the improvements needed in furnace operation to burn it properly. The producer plant tests were highly satisfactory, showing that the coal could thus be utilized without special treatment and that the gas operated satisfactorily in the gas engine, giving a coal consumption in some of the longer tests of about 6½ lb. of coal as fired per kw-hr. at the switchboard for power available for outside purposes. If the power consumed by the gas scrubber was reduced to as small an amount as possible and the generator had been operated at more nearly its rated capacity, the results would have made a much better showing.

EXPERIMENTS WITH NORTH DAKOTA LIGNITE IN A STEAM POWER PLANT AND A GAS PRODUCER

By Calvin H. Crouch, Grand Forks, N. D.

Member of the Society

North Dakota has an area of approximately 70,000 square miles, of which about one-half is underlain with workable seams of lignite coal, varying from a few feet to 35 feet in thickness, which it is quite probable will some day exert a great influence upon its manufacturing and engineering industries. According to the State Geological Survey reports, the number of workable beds in southwestern North Dakota in 1908 were known to be 21. These are distributed through from 1000 to 1300 ft. of strata and range from 4 to 35 ft. in thickness. The aggregate thickness of the coal in these beds is 157½ ft.[1] Figs. 1 and 2 show the way in which the coal crops out[2].

2 It has been estimated by some that the North Dakota lignite deposits comprise one-sixth of the known coal deposits of the United States, but their extent and value are doubtless unappreciated, if indeed they are known, by the majority of the citizens of the State. Comparatively small amounts of the coal are mined annually, though the amount is increasing and will doubtless increase even more rapidly as the people learn to appreciate its value and to burn it in such a manner as to utilize more fully its heat units. It is regarded by many as an almost worthless fuel because it will not stand shipping in dry, warm weather without disintegrating and because it has been used in the ordinary furnace under boilers with poor results. It is used principally at points near the mines for power and domestic purposes and with

[1] N. D. State Geological Survey, 2d, 3d, and 5th biennial reports.

[2] N. D. State Geological Survey, 1908, Plates 13 and 15.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

the present cost at the mine and freight rates and the present method of burning, it does not seem able to compete with the cheaper grades of Eastern bituminous coal at points a few hundred miles from the mines. Its use, however, is increasing, as shown by a statement received from the state engineer's office

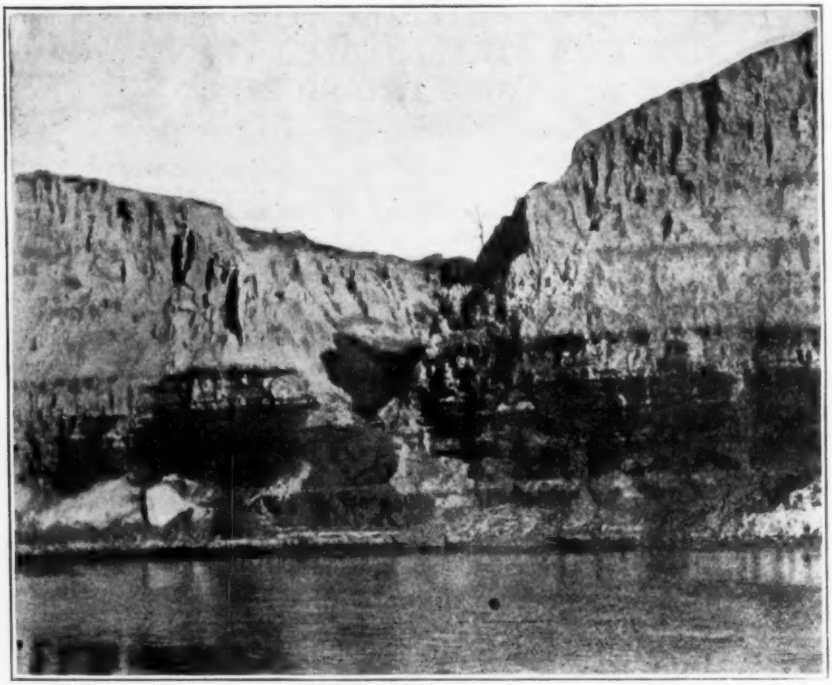

FIG. 1 COAL BED OF THE GREAT BEND GROUP EXPOSED ON LITTLE MISSOURI NEAR THE HARMON RANCH. TOTAL THICKNESS OF COAL, 16 FT.

that 271,928 tons were mined in 1904, 385,882 tons in 1910, and 466,600 tons in 1911.

PRELIMINARY EXPERIMENTS

3 Before presenting and discussing the results of the experiments with North Dakota lignite as a fuel in a steam and producer gas power plant, the author will present the results of some rather simple but interesting preliminary experiments with the same coals as were used in the power plant tests. They show the nature of the fuel and its behavior when exposed to heat and

FIG. 2 COAL BEDS OF THE MEDORA GROUP EXPOSED ON LITTLE MISSOURI RIVER NEAR THE MOUTH OF ASH CREEK. TOTAL THICKNESS OF COAL, 16 FT. 5 IN.

to the drying action of the atmosphere and throw much light upon the results obtained in the power plant tests.

4 The coal used consisted of two car loads, one shipped in January 1911, from Williston, N. D., here designated as coal No. 1, and a second from Wilton, N. D., shipped in August 1911, referred to as coal No. 2.

5 Three samples of coal No. 1, weighing about 14 lb. each, were taken from different sections of the pile and weighed, submerged in water for 48 hours and again weighed. The gain in weight was but a fraction of 1 per cent, indicating that the coal was practically saturated with water when mined as it was shipped in cold weather and could not have given up or taken up much moisture in transit.

6 Coal No. 2 was shipped in August 1911, and was stored out of doors until needed for the tests. It was exposed to the elements during the summer and fall and naturally gave up some of its surface moisture, but the coal in the interior of the pile was quite wet in the winter when the tests were made. A block of this coal weighing 12 lb. 10 oz., which was taken from a point 2 ft. beneath the surface of the pile, submerged in water for 48 hours and again weighed, gained 14 oz., or 6.9 per cent in weight. The author was not present when coal No. 2 was received, hence, samples were not taken at that time.

7 To show the readiness with which the lignite gives up its moisture, four samples weighing respectively 30, $38\frac{1}{2}$, 74 and 83 lb. were taken from coal No. 2 and placed in a room on March 16, 1912, and weighed from time to time. During the first week, the temperature was about 60 deg. fahr. and during the remainder of the time about 70 deg. On March 18, the coal had given up 2.43 per cent of its weight, on March 20, 3.76 per cent, on March 21, 6.09 per cent, on March 27, 9.2 per cent, April 1, 11.31 per cent and on April 16, 12.63 per cent. Figs. 3, 4, 5 and 6 were taken of these four samples on March 18, 20, 27 and April 16 and show the way in which the coal disintegrated as it dried. Fig. 7 shows the results after these four samples had been dropped 8 ft. upon a concrete floor, and indicates that when the coal is dry it is very friable.

8 To show how the coal disintegrates when stored for some time under cover, on April 6, 1912, a sample of 100 lb. was taken from a bin inside the building which had been filled with coal

No. 2 since August 1911. The bin contained about 4 tons. A small proportion of the coal (perhaps one-sixth) was in large chunks ready to fall into pieces with a light blow. The coal had been pulverized somewhat by firemen in shoveling it from the bin. However, neglecting the large chunks, the sample was a fair average of the coal. This sample was screened successively on sieves with 1/8 in., 1/4 in. and 1/2 in. mesh; that which remained on the finer sieve was screened on the next coarser. Of the coal 26 1/2 per cent passed through the screen with the 1/8 in. mesh, 24 1/2 per cent passed through the screen with the 1/4 in. mesh, 18 per cent passed through the screen with the 1/2 in. mesh and 31 per cent remained on the last. All would have passed through a 2 1/2 in. ring.

9 Numerous proximate analyses were made, the results of which showed the green coal to contain approximately 35 per cent of moisture, and the dry coal to contain approximately 43 per cent of volatile matter, 50 per cent of carbon and from 7 to 9 per cent of ash. Difficulty was experienced in determining the percentage of moisture. It was finally decided to call that moisture which was driven off at a temperature below 240 deg. fahr. It was thought that some of the volatile matter was driven off at temperatures slightly above that. It was readily seen that gases were driven off at comparatively low temperatures as shown by the analytical balance and by the odors given off.

10 North Dakota lignite is classed as one of the youngest coals. In appearance it is black when freshly mined, but as it dries, it becomes lighter in color and is often a dark brown. Before it has become sufficiently dry to disintegrate, it somewhat resembles charcoal in that it frequently shows very clearly the grain of the wood and knots of the trees from which the coal has been formed; but upon drying it cracks both with and at right angles to the grain as seen in Figs. 3-7. The line of cleavage in breaking is along the grain. Occasionally a piece will be found which has lost its grain and at fracture resembles anthracite in appearance, having a luster, but this disappears as the moisture is driven off.

11 From these preliminary experiments, it will be seen that this fuel may contain (*a*) large quantities of moisture, the two coals analyzed containing over 35 per cent of moisture, which is readily given up, causing the coal to crack and disintegrate; (*b*)

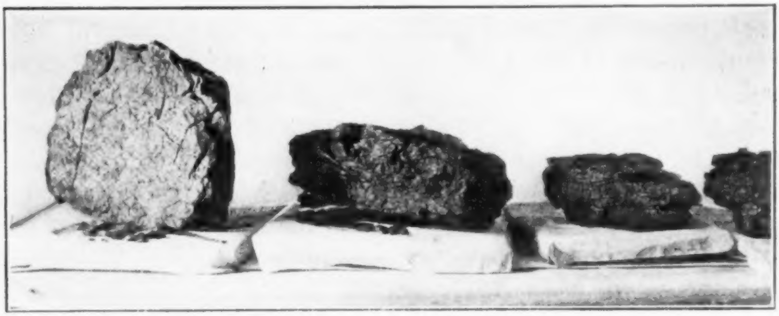

Fig. 3 Coal after being 2 Days inside of Building

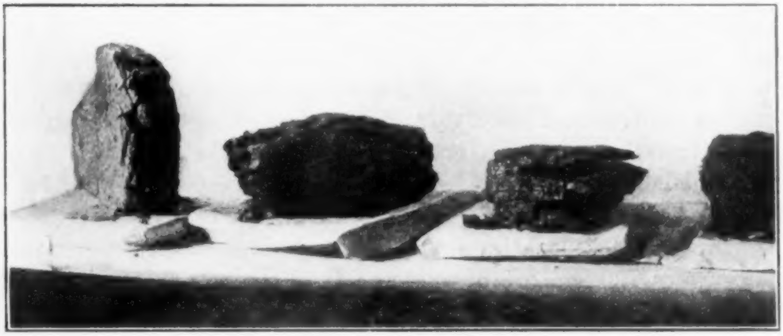

Fig. 4 Coal after being 4 Days inside of Building

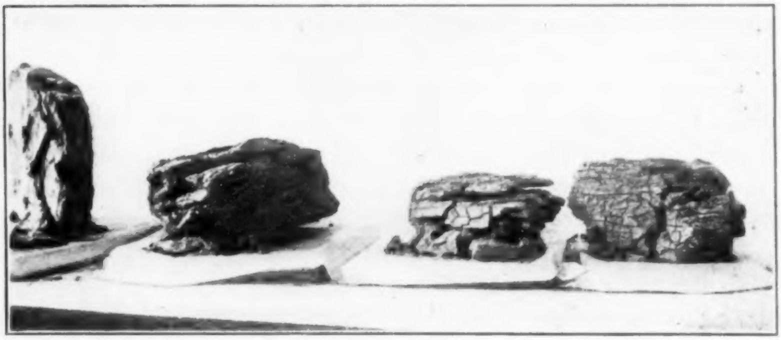

Fig. 5 Coal after being 11 Days inside of Building

large proportions of volatile matter, some of which is driven off at comparatively low temperature; and (*c*) a small percentage of ash. These characteristics are very important and must be taken into consideration when designing furnaces and gas producers to utilize it. In the furnace it disintegrates and if burned

FIG. 6 COAL AFTER BEING 31 DAYS INSIDE OF BUILDING

FIG. 7 SAMPLES OF COAL AFTER FALLING 8 FT. UPON A CONCRETE FLOOR

on grates suitable for a coking coal, it will, when heated to red. run through the grate like so much coarse sand, especially if it be disturbed with a slice bar. Thus it will be seen that it should be burned on a grate with small openings and with a strong draft, for when it disintegrates it settles or packs down, restricting the air passages. One would also expect, since it contains a large proportion of volatile matter, that fire-brick arches or dutch ovens would be desirable in burning it under boilers.

12 An appreciation of these important properties and characteristics shown by the preliminary experiments will help in understanding the difficulties experienced in conducting the evaporative and gas producer tests and interpreting the results.

EVAPORATIVE TESTS

13 Evaporative tests, using North Dakota lignite under the boilers, were made in the mechanical laboratory of the College of Mechanical and Electrical Engineering at the State University of North Dakota. This plant consisted of two 70-h.p. horizontal fire tubular boilers, one of which was equipped with a Detroit automatic stoker and a dutch oven 7 ft. long projecting out in front of the boiler, while the other was provided with an ordinary furnace and rocking grates which were suitable for burning eastern bituminous coals. After several preliminary experiments, this last-mentioned furnace was modified by placing fire-brick arches or tiles over three-fourths of the grate and by substituting perforated plates for the rocking grates, the perforations being ½ in. in diameter and 35 per cent of the area of the grate.

14 The plant was provided with natural draft which was adequate when burning Eastern bituminous coal to drive the boilers much beyond their rated capacities, but which proved inadequate when burning lignite. Several tests were conducted, varying from four to ten hours in duration. While they were unsatisfactory in that the boilers could not be driven at their rated capacities, they indicated conclusively that a much stronger draft would be necessary to keep the furnaces at a white heat and to force the boilers to their rated capacities. A small fan was available for producing a forced draft. It was not large enough to supply the necessary pressure but served its purpose for, with it, the furnace could be kept at a white heat, which was impossible without it. It was not thought advisable, however, to drive the fan at the necessary high speed for any considerable time and the results obtained with natural draft had to suffice. The author, wishing to confirm the results secured in 1911 by the students, conducted three tests in the spring of 1912, with about the same experience and results. Funds were not available at the time for the installation of an induced draft so that elaborate tests were not undertaken, the experiments being valuable chiefly because of the experience and knowledge gained. It was clearly

demonstrated that with a dutch oven and a mechanical stoker with proper draft conditions, the coal can be economically utilized in a steam power plant.

15 Table 1 gives the more important economic results obtained from these preliminary evaporative tests. For comparison the average of the results of 15 tests made by the U. S. Bureau of Mines, with this coal in a specially constructed furnace has also been included.[1]

TABLE 1 EVAPORATIVE TESTS

Furnace	Grate Area, Sq. Ft.	Duration of Tests, Hours	Per Cent Moisture in Coal	Dry Coal burned per Sq. Ft. of Grate Surface per Hour	Equivalent Evaporation from and at 212 Deg. per Lb. of Coal as fired	Equivalent Evaporation from and at 212 Deg. per Lb. Dry Coal	H.P. in Per Cent of Builders' Rating
Detroit stoker and dutch oven.....	20.25	10	35.77	12.20	4.22	6.58	67.4
Perforated plate grates with arches over 3/4 of the grate....	16	12	35.77	14.58	3.638	5.66	54.7
Special furnace used by Bureau of Mines.......	.....	....	43.27	25.18	3.49	6.09	73.9 to 103.3

16 It will be noted that although the boilers were forced as hard as possible in the tests conducted by the author, they developed only from 54.7 to 67 per cent of the builders' rated capacity. In burning the coal on the chain grates under water tube boilers in the university power plant which had natural draft, a similar experience resulted. The experiment was begun with the furnace at a white heat, but as the lignite was fed into the furnace the fire-brick arches and tile on the water tubes cooled to a much lower temperature and the boiler could not be driven at anything like its normal rating.

17 An induced draft system was recently installed in the university power plant, and an induced draft apparatus has been ordered for the experimental plant in the mechanical laboratory

[1] Bulletin No. 2, Bureau of Mines, pp. 18, 19.

which will be capable of giving almost any amount of draft that may be desired in connection with a series of tests which will doubtless be conducted in the near future.

GAS PRODUCER TESTS

18 Experiments with North Dakota lignite in the gas producer were conducted in the same laboratory, the object being to determine the feasibility of using this fuel in a producer gas power plant.

APPARATUS

19 The experimental plant consisted of a 50-h.p. Smith suction down-draft gas producer and a 55-h.p. Alberger tandem producer gas engine belted to a dynamo. The scrubber was driven by an independent motor. In the tests of 1911, the jacket and scrubbing water was supplied from the city mains but for the 1912 tests a motor-driven triplex pump was installed so that the cost in power of supplying this water could be determined. In the 1911 tests, the dynamo used to load the engine was a 25-kw. direct-current machine, but for the subsequent tests a 45-kw. direct-current three-wire generator with compensating coils was installed so as to be able to load the engine to its maximum capacity. Fig. 8 shows a sectional view of the gas producer and Fig. 9 a sectional view of the engine.

METHOD OF LOADING THE ENGINE

20 The engine was loaded by means of a dynamo which supplied current to the university light and power circuit and also to a water rheostat which could be used when there was not sufficient demand otherwise for power to utilize all that was produced. The dynamo was so connected that current could be taken from the main line to drive the generator as a motor in starting up the engine. This made a simple and very satisfactory way of starting the engine which, when started, would speed up, increasing the generated electromotive force, and cause the motor to become a generator supplying current to the line, the load carried by the dynamo being governed by the voltage which was controlled by a hand-regulated field rheostat.

21 The generator used during the tests Nos. 1-8 inclusive was an old 25-kw. direct-current generator formerly used in the university lighting plant; in tests Nos. 9-18 inclusive a new Fort

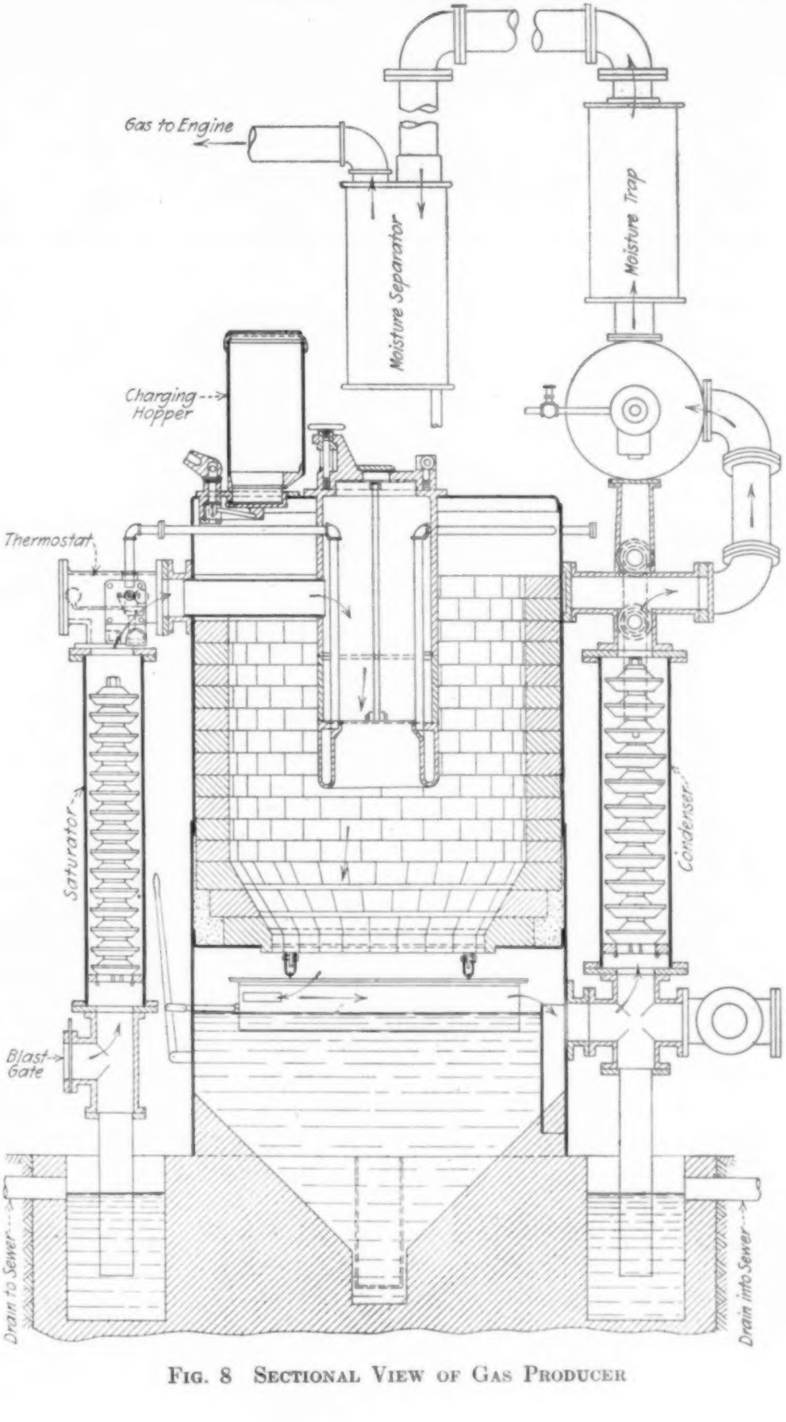

FIG. 8 SECTIONAL VIEW OF GAS PRODUCER

Wayne machine. This machine started up nicely but before test No. 12 had been finished, the commutator had become warped or out of true, causing much sparking at the brushes. This was remedied, however, before test No. 13 was run by turning down the commutator, after which it gave no trouble.

METHOD OF DETERMINING THE POWER GENERATED, AND COAL CONSUMED

22 The power delivered to the switchboard by the generator was measured, and the coal consumed per kw-hr. at the switch-

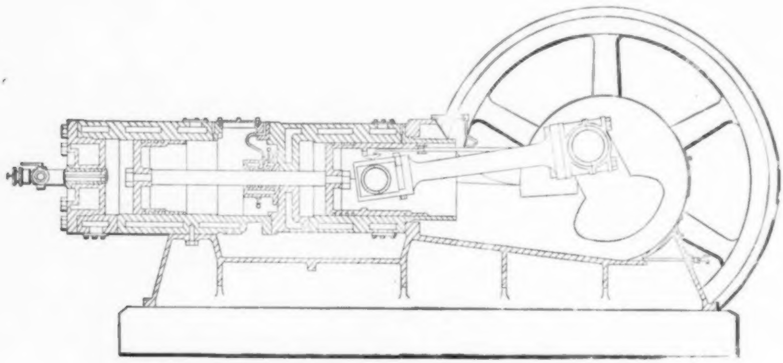

Fig. 9 Longitudinal Section of Gas Engine

board determined. It was the original intention to determine the efficiency of the generator so as to get the total power developed by the engine, but time did not permit before the armature of the generator was needed to replace a burned-out armature in a motor in the university power plant, so that the windage, friction and internal losses of the generator used in 1911 could not be obtained. However, since the machine was loaded to nearly its rated capacity most of the time, it was assumed in determining the brake horsepower of the engine that the generator had an efficiency of 90 per cent and that the belt transmission gave an efficiency of 98 per cent, both of which are probably higher than their true value.

23 As no means was at hand for measuring or determining the amount of water used by the engine jackets or the gas scrubber in the tests of 1911, accurate records of the power used by the

scrubber were not taken. To determine the net power available for outside purposes, it would be necessary to charge against such a plant all of the power consumed by the auxiliary apparatus. Fortunately funds were available in the fall of 1911 so that a motor-driven triplex pump was installed to supply the jacket and scrub water, also a more efficient motor was installed for driving the scrubber. In determining the net power available for outside purposes in the tests of 1911, it was assumed that the power consumed by the auxiliaries was the same as during the tests of 1912 when apparatus was available.

24 In determining the power developed by the engine in the tests of 1912, it was assumed that the belt transmission gave an efficiency of 98 per cent. The losses in the generator were determined by experiments in which the windage, friction, iron and copper losses were carefully determined and curves plotted showing the efficiency of the generator at various loads. The low efficiency of the generator may doubtless be explained by the fact that the machine was developing but little more than 50 per cent of its rated capacity.

25 In determining the coal used during the test, care was taken that the producer was full when the test began and when it ended. The coal charged in the meantime was considered as the coal used during the test. Before starting up the blower for the next test, the producer was poked to make sure there were no large voids and filled as before. The coal charged at this time was called the "standover" losses. A similar method was followed after fire had been "blown up" and the amount needed to fill the producer just before starting the test was called the "starting-up" losses.

COAL AND GAS ANALYSES

26 At the beginning of the first series of tests, Nos. 1-8, Table 2, the apparatus for analyzing the gases was broken so that but one analysis of the gas of these eight tests was made. Proximate analyses of the coal used in each test were made to determine the moisture. In the second and third sets of experiments, or those conducted in 1912, a complete analysis of the gases was made. The incomplete determinations of CO_2, O and CO were made with the Orsat flue gas apparatus. It is interesting to note that the composition of the two coals was almost identically the same.

TABLE 2 GAS PRODUCER PLANT POWER TESTS

No. of Test	Duration, Hr.	Coal Used	Moisture in Coal, Per Cent	Dry Coal Used	Moisture in Coal, Per Cent	Dry Coal Used	Coal as Fired per Hour	Dry Coal Used per Hour	Kw. Delivered at Switchboard	Kw. Consumed by Scrubber and Pump	Kw. at Switchboard Available for Outside Purposes	Power Consumed by Generator, H.P.	Brake H.P. of Engine Assuming an Efficiency for the Belt Transmission of 98 Per Cent	Coal as Fired per Kw-Hr. at Switchboard
1	8	632	32.9	424.1	32.9	424.1	79.0	53.0	14.18	3.71	10.47	.....	16.07	5.57
2	8	1017	33.1	680.4	33.1	680.4	127.1	85.0	21.21	3.71	17.50	.....	24.04	5.99
3	7¼	875	35.9	560.9	35.9	560.9	120.6	77.2	20.86	3.71	17.15	.....	23.65	5.77
4	27½	2575	16.0	2163.0	16.0	2163.0	93.6	78.6	22.64	3.71	18.93	.....	25.66	4.13
5	4	425	35.8	272.9	35.8	272.9	106.2	68.2	21.24	3.71	17.53	.....	24.08	5.00
6	8	850	38.0	527.0	38.0	527.0	106.2	65.8	21.27	3.71	17.56	.....	24.11	4.99
7	16	1700	36.5	1079.5	36.5	1079.5	106.2	67.4	22.67	3.71	18.96	.....	25.70	4.68
8	6¼	500	37.2	314.0	37.2	314.0	76.9	48.3	18.5	3.71	14.79	.....	20.97	4.10
9	24	2960	20.4	2356.0	20.4	2356.0	122.3	98.1	18.3	3.71	14.59	28.71	29.21	6.68
10	9½	1255	20.4	999.0	20.4	999.0	131.5	105.1	19.36	3.71	15.65	30.16	30.78	6.78
11	11½	1365	20.4	1086.0	20.4	1086.0	118.7	94.1	19.87	3.71	16.16	30.88	31.49	5.98
12	12	1125	20.4	895.0	20.4	895.0	93.7	74.5	19.12	3.71	15.41	29.82	30.43	4.90
13	9¾	1205	35.77	774.0	35.77	774.0	123.6	79.38	22.78	3.71	19.07	34.94	35.66	5.42
14	5 1/3	1072	33.0	718.0	33.0	718.0	201.1	134.7	21.31	3.71	17.60	32.91	33.58	9.43
15	9	1478	23.35	1132.0	23.35	1132.0	164.2	125.7	22.99	3.71	19.28	35.03	35.74	7.14
16	11	1351	23.35	1035.0	23.35	1035.0	122.8	94.0	22.88	3.71	19.17	34.92	35.64	5.36
17	7 2/3	820	23.35	628.0	23.35	628.0	107.0	82.0	24.54	3.71	20.83	37.37	38.13	4.40
18	24	3013	23.35	2309.0	23.35	2309.0	125.0	96.2	23.18	3.71	19.47	35.45	36.17	5.39

TABLE 2—Continued

No. of Test	Coal as Fired per Kw-Hr. Available for Outside Purposes	Coal as Fired per Brake Hp-Hr.	Dry Coal per B.H.P-Hr.	CO_2, Per Cent	O, Per Cent	CO, Per Cent	H, Per Cent	CH_4, Per Cent	N, Per Cent	Number of Samples Analyzed	B.t.u. per Cu. Ft.	Suction in Inches of Water at: Engine Throttle	Scrubber	In Pit below Grate	Air Inlet
1	7.56	4.92	3.29	....	....	....	....	....	....	....	....	....	....	....	....
2	7.26	5.28	3.53	....	....	....	....	....	....	....	....	....	....	....	....
3	7.02	5.10	3.26	....	....	....	....	....	....	....	....	....	....	....	....
4	4.94	3.65	3.06	5.10	4.65	17.58	9.31	2.3	61.06	....	111.4	....	....	....	....
5	6.05	4.41	2.83	....	....	....	....	....	....	....	....	....	....	....	....
6	6.05	4.40	2.72	....	....	....	....	....	....	....	....	....	....	....	....
7	5.61	4.13	2.62	....	....	....	....	....	....	....	....	....	....	....	....
8	5.20	3.66	2.30	....	....	....	....	....	....	....	....	....	....	....	....
9	8.38	4.22	3.35	11.9	2.4	11.6	....	....	....	2	....	15.8	13.6	4.9	0.25
10	8.40	4.27	3.41	9.2	2.5	16.7	....	....	....	2	....	20.7	15.2	7.3	0.7
11	7.34	3.77	3.00	10.8	2.3	14.0	....	....	....	3	....	21.9	17.4	7.6	0.1
12	6.09	3.08	2.44	10.0	2.6	12.5	....	....	....	4	....	21.1	16.8	10.7	0.18
13	6.00	3.46	2.22	9.8	1.0	10.8	....	....	....	3	....	23.0	20.0	6.0	0.2
14	11.42	5.99	4.01	....	....	....	....	....	....	....	....	23.6	18.0	4.61	0.7
15	8.52	4.59	3.51	....	....	....	....	....	....	....	....	23.4	19.1	4.4	0.5
16	6.40	3.44	2.63	9.13	1.64	14.11	16.53	0.88	57.7	12	109.85	18.2	16.0	7.5	1.27
17	5.13	2.8	2.15	6.08	3.8	10.62	18.97	4.2	56.25	4	152.7	26.9	20.8	4.7	0.07
18	6.45	3.47	2.65	8.59	3.7	11.7	8.04	4.77	63.18	9	115.42	28.8	21.7	7.5	0.33

Tests Nos. 1–8 were made between February 2 and May 24, 1911; tests Nos. 9–18 between February 6 and May 10, 1912. In all of these a Smith suction down-draft 50-h.p. gas producer and an Alberger tandem 55-h.p. gas engine were used; while in Nos. 1–8 a Westinghouse 25-kw. and in Nos. 9–18 a Fort Wayne 45-kw. generator was employed. The lignite coal in Nos. 1–8 was from the J. Bruegger mine, Williston, N.D., and in Nos. 9–18 from the Washburn Mine, Wilton, N. D. An analysis of samples taken from piles out of doors showed for coal No. 1, volatile matter, 44.2 %; fired carbon, 50.1 %; ash, 5.7 %; moisture, 35.9 %; for coal No. 2, volatile matter, 43.58 %; fixed carbon, 50.33 %; ash, 6.09 %; moisture, 35.77 %.

DESCRIPTION OF TESTS

27 Test Nos. 1-8 inclusive were conducted at intervals of from one to two weeks apart. After a test had been run, the producer was filled and enough coal brought into the building during the following week to run the next test. This enabled much of the coal to thaw out, though frequently coal was charged into the producer in the frozen state. The coal used in test No. 4, however, had been in the boiler room for some weeks which caused it to be much drier than that used in the other seven tests, but the author is inclined to believe that the 16 per cent moisture recorded is much too small. It is possibly due to poor sampling or to the loss of moisture between date of sampling and date of analyzing.

28 These tests were conducted with the idea of getting the maximum power possible out of the engine, but the capacity of the generator limited this, while tests Nos. 8-12 were planned to determine the efficiency of a plant, such as an electric light plant where the load would be variable and the plant operating from but 6 to 12 hours per day, standing idle the remainder of the 24 hours. For this reason, little effort was made to keep the load uniform. Ammeter and voltmeter readings were taken at half-hour intervals, but the power consumed during these four tests was measured by means of a carefully calibrated watt-hour meter. The power developed during tests Nos. 1-8 was determined from the ammeter and voltmeter readings which were taken every 15 minutes; during tests Nos. 13-18 inclusive, the power was likewise determined but the readings were taken at intervals of 20 minutes each, the loads in tests Nos. 1-8 and in 13-18 being kept as nearly uniform and as large as seemed feasible.

TROUBLES EXPERIENCED

29 It was observed that at the engine throttle, in the scrubber suction and in the pit beneath the grate of the producer, the suction increased as the tests progressed, apparently due to fine ash and clinkers closing up the air passages. This would restrict the gas at the engine causing its speed to reduce, which in turn would lower the voltage and cause the load to be thrown off automatically.

30 On one occasion the suction became so great that air

was pulled down through the ash conveyor into the bottom of the producer, with a resulting explosion that shook the fire up violently, blowing much fine ash out through the top of the central tube, which happened to be open. The engine automatically threw off its load, the dynamo operating as a motor driving the engine until the spent gases had been exhausted, when the engine immediately speeded up and took on its normal load. The suction at the different parts of the plant was greatly reduced after this explosion so that it operated satisfactorily during the remainder of the test.

31 Another source of trouble was that the strong suction would pull ash and fine particles of coal over into the bottom of

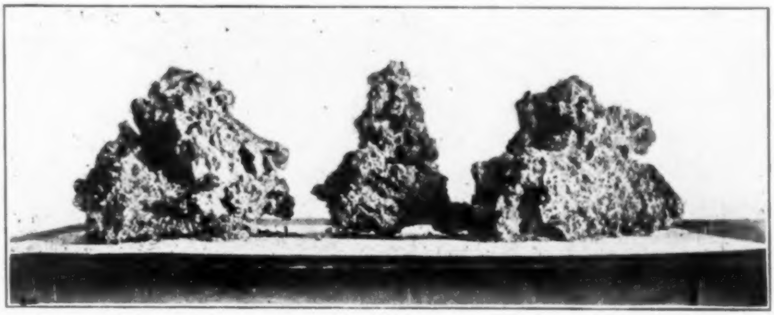

FIG. 10 CLINKERS TAKEN FROM GAS PRODUCER

condensing chamber which gradually became clogged and finally shut off the supply of gas with the natural results.

32 It is possible that with more experience the producer might be operated to fuse practically all of the ash into large clinkers, which could be removed through the top of the central tube of the producer. A large part of the ash was thus fused but evidently enough escaped to cause trouble. Fig. 10 shows some of the clinkers removed.

33 The disintegrating action of the coal when subjected to a high temperature caused the coal to settle down and the bed to become dense with restricted air passages, which also tended to increase the suction. Violent shaking of the grate seemed to help reduce this high suction and occasionally the suction would drop to but a few inches when large clinkers were removed.

34 It was observed in conducting the preliminary tests of

1912 when running tests on successive days using fuel with a large percentage of moisture, that the engine would satisfactorily carry its load during the first five or six hours and then the fire would become chilled and the gas so poor that the engine would scarcely run with no load. It was also observed when this happened that the fire in the producer had burned unevenly, being hotter on one side than on the other, doubtless allowing air to pass down through the bed without burning the coal. This action can perhaps be explained by the fact that the coal which had stood in the producer over night had become sufficiently dry to burn satisfactorily and that the trouble began when the fresh coal charged during the test reached the fire zone, chilling the fire because of its large amount of moisture and causing it practically to die out in certain sections and to become black at the lower end of the central tube where the fire was usually bright when operating under normal conditions.

35 The trouble is one that can be easily overcome either by drying the coal before shipping from the mine or by storing it for a few weeks in a dry, warm place where it will readily give up a large part of its moisture.

REMARKS

36 The starting and standover losses of the producer plant were surprisingly small. From a number of records made, it was estimated that the starting-up losses did not exceed 50 lb. even when the producer had been standing idle for one or two weeks and required 35 to 45 minutes to get good gas. The starting-up losses when the producer was operated on successive days were much less as good gas would be delivered at the engine in from 10 to 20 minutes from the time the blower was started. The engine would often carry full load within 15 or 20 minutes after starting the blower.

37 The standover losses for fourteen different observations covering 867 hours amounted to 3043.5 lb. or an average of 3.3 lb. per hour. The periods of standover varied from 12 to 300 hours, the standover losses for the short periods being more per hour than for the long periods. Taking 777 hours of the longer standover periods, the average per hour of the standover losses was but 1.92 lb. per hour. Comparing the starting-up and standover losses of the producer gas plant with those of a steam

plant, the author believes the former has a decided advantage over the latter.

38 It should also be borne in mind that a commercial plant would doubtless be much larger than this experimental plant and would give correspondingly better results. Furthermore, it is quite possible that the power consumed in scrubbing the gas was much larger than was necessary, as it was feared trouble would arise from tar getting into the engine.

39 Doubtless a larger amount of scrub water was used than was necessary, thus greatly increasing the amount of power consumed in scrubbing the gas. The amount of power consumed by the scrubber could be doubled or trebled simply by increasing the quantity of scrub water used. No trouble was experienced, however, from tar getting into the engine cylinders. The cylinder head of the engine was removed for inspection from time to time. A small amount of gummy substance adhered to the counterbore of the cylinder but the cylinder barrel was well lubricated. It was thought that the substance adhering to the counterbore was largely cylinder oil and carbon partially burned, but it may have been partially burned tar. In either event, there was not enough to cause the piston rings to stick or leak or to interfere with the action of the admission and exhaust valves.

40 A lengthy discussion comparing the economic results of the coal consumed per brake horsepower or per kw-hr. at the switchboard with the amounts required by steam plants of similar size is not necessary. It should be apparent to all that the cost of power in terms of pounds of lignite per b.h.p. or per kw-hr. at switchboard is much less than it would have been in a steam power plant of like size.

41 None of those interested in these tests was familiar with the operation of gas producers so that all had much to learn about the care and manipulation of the plant. Doubtless much better results would have been secured by those experienced in the handling of this type of plant. The author, however, feels gratified with the results for it should be expected that with more experience in handling the producer a much better economy would be obtained.

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AXIOMS CONCERNING MANUFACTURING COSTS

By Henry R. Towne

BRIEF

In a paper entitled The Enginner as an Economist, contained in Volume 7 of the Transactions, 1886, by the present writer, is the following statement:

"To insure the best results, the organization of productive labor must be directed and controlled by persons having not only good executive ability, and possessing the practical familiarity of a mechanic or engineer with the goods produced and the processes employed, but having also, and equally, a practical knowledge of how to observe, record, analyze and compare essential facts in relation to wages, supplies, expense accounts, and all else that enters into or affects the economy of production and the cost of the product."

The following paper attempts to sum up the results of modern experience in these matters, and to state the views now generally held concerning the fundamental principles which underlie industrial accounting. The conclusions reached are embodied in the Axioms; the arguments on which the latter are based are contained in the intermediate text.

AXIOMS CONCERNING MANUFACTURING COSTS

By Henry R. Towne, New York

Member of the Society

Three factors enter into the cost of each and every article of manufacture; namely, *materials*, *labor* and *expenses*. These constitute a tripod, a three-legged stool, which cannot stand if one of these legs be omitted. They may, and do, vary in dimension, but all three are invariably present, and a "cost" which omits any one of them is incomplete and fallacious. The formula is

$$L+M+E=C$$

in which L represents labor, M materials, E expenses and C cost. In this primary division the item "labor" includes all labor entering directly into the product, the item "material" all material entering directly into the product, and the item "expenses" (often called overhead charges, or simply overheads) all other labor, material and expenditures of every kind whatsoever.

Axiom 1 Every cost includes three fundamental factors: labor, material, expenses.

2 In most cases, however, the expenses, or overheads, divide naturally into two groups:

a Manufacturing expenses, those incident to the operation of the factory or mill; that is, those incurred in utilizing productive labor and material, and in bringing the product up to the point where it is ready to be sold.

b Commercial expenses, those incident to the commercial department of the business, including administration, salesmen, advertising, office expenses, etc.; that is, those incurred in distributing and selling the finished product.

It is highly expedient that these two should be segregated, so that each may be studied separately.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

Axiom 2 The expense factor should be split into two parts: manufacturing, commercial.

3 Letting the symbol *Me* represent the former, and the symbol *Ce* the latter,

$$L+M+Me+Ce=C$$

But a more convenient and indicative form of presenting these elementary facts, one which the writer has used for many years, is the following:

L = productive labor
M = productive material
$\overline{PC}$ = *prime cost*
Me = manufacturing expenses
$\overline{SC}$ = *shop cost*
Ce = commercial expenses
$\overline{AC}$ = *actual cost*

4 If preferred, the foregoing facts may be expressed by the following formulae:

$L+M=PC$ or *prime cost*
$PC+Me=SC$ or *shop cost*
$SC+Ce=AC$ or *actual cost*

Axiom 3 A manufacturing cost has three phases: prime cost, shop cost, actual cost.

5 On the appreciation and intelligent use of these facts hang all the laws of good business and the profits, for no business can long be operated successfully without a correct knowledge of costs, nor can that be had without a clear grasp of fundamental principles. The competitor most to be feared, while he lasts, is one who does not know his costs, nor understand how to obtain them.

Axiom 4 Accurate cost information is vital to good management.

6 Simple as are these elementary principles, their correct application in each given case is difficult, and calls for great care and intelligence. To draw correctly the line between productive and non-productive labor and material, through each of the successive stages of a productive industry, requires the combined skill of the expert manufacturer and the expert industrial accountant; the former knowing accurately all the details of the manufacturing or productive processes, and the latter knowing equally the proper methods of combining and using the recorded facts to yield the desired information. For example, what constitutes productive

labor? In the case of a machinist operating a lathe clearly it includes his wages while his lathe is turning out product and also while it is standing still during the time he is dressing the tool to do the work properly. But if the tool-dressing is done for him, as it is under good modern practice, how shall the time and wages of the tool-dresser be classified? So as to productive material, shall the tool, the file, the waste, the oil, which are consumed or used up in making the product be classified as productive or as non-productive material? The answers to these questions depend on the surrounding facts in each case, and are as varied as the cases are infinite in number and variety. The writer is not attempting here to answer such questions, but merely to point out and emphasize underlying principles. This much is clear, that every individual item of expenditure, large and small, must ultimately classify under one of the three great heads above referred to, labor, materials or expenses, and that profit, or loss, is the difference between actual cost and the net price realized.

Axiom 5 Accurate costs imply the correct classification of every expenditure.

7 The distribution of actual costs among these heads, or, preferably, into the four groups or divisions indicated above, varies widely in different industries and with different products. This is illustrated by the following table, relating to four distinct lines of actual product, in which the several elements have been reduced to terms of the actual cost of the product when finished and sold.

Nos.	1	2	3	4
L = productive labor........	28	17	29	19
M = productive material.....	38	33	25	37
PC = prime cost..........	66	50	54	56
Me = manufacturing expenses..	24	20	28	22
SC = shop cost...........	90	70	82	78
Ce = commercial expenses.....	10	30	18	22
AC = actual cost.........	100	100	100	100
Total expenses (that is, $Me+Ce$) =	34	50	46	44

8 The figures in the above table illustrate the hopeless state of mind of manufacturers, some of whom still survive, who delude themselves by the belief that the sum of labor and materials (prime cost) represents the actual cost of the product, and that the difference between that and the selling price is profit. They show, on the contrary, that, in the four examples to which the figures relate, the

prime cost constitutes only from one-half to two-thirds of the actual cost, and that the expenses, or overheads, incident to conducting the business and marketing the product, contribute from one-third to one-half of the total or actual cost. It seems probable that, if the facts concerning all manufacturing industries could be ascertained and averaged, the "three-legged stool" would be found to stand nearly level, its three legs being approximately of equal length, although differing widely in individual cases.

9 All cost accounting should aim to segregate charges wherever this can be done accurately. Thus the major part of the items constituting productive labor and material can and should be charged directly to their respective accounts, L and M.

Axiom 6 Every productive expenditure should be charged directly to its proper account.

10 All other items, however, which cannot be so segregated must be aggregated into one or several groups and their total apportioned among the proper accounts on some carefully determined but necessarily arbitrary basis.

Axiom 7 All non-productive expenditures should be properly grouped for final distribution.

11 Manufacturing expenses may be apportioned as a ratio or percentage of labor L, of material M, or of labor and material $L+M$. The usual bases are either L or $L+M$. The writer believes that in most cases the closest conformity to actual facts will be attained by distributing manufacturing expenses in the ratio of productive labor, hand and machine, because usually the volume of indirect expenses of works operation will be far more influenced by the pay-roll, that is, by the number and kinds of employees, than by the materials bill, that is, the amount paid for the material of production. Moreover, the former is relatively stable, while the latter fluctuates with market changes. Therefore it is advisable that Me should be a function of L, that manufacturing expenses should be apportioned as a percentage of productive labor, although in some cases they may properly be apportioned per machine, or per unit of floor space.

Axiom 8 The normal basis for distributing manufacturing expenses is productive labor.

12 Commercial expenses may also be apportioned as a percentage of L, of M, or of $L+M$, and frequently are, but more properly they should be apportioned on the basis of shop costs, $L+M+Me$. The reasons for this are conclusive. Production and selling are two sepa-

rate and distinct processes. The former brings the product to the point where it is completed and ready for sale; the latter then takes it over and effects the sale. The expenses incurred in each process are for its use only, and have no natural relation to the needs and uses of the other. To illustrate this, take the case of a manufacturer of cotton cloth who sells his entire product through a commission house or broker. Clearly his whole commercial expense account is covered by the commission he pays to his selling agent, and this bears a definite ratio to his shop cost, that is, to the cost of his product ready for sale. Now, take the case of another manufacturer of cotton cloth, who maintains his own selling organization and through it distributes his product. Clearly his commercial expenses offset the commission paid by his competitor, and equally bear a definite ratio to his shop cost. Both are most accurately stated and apportioned as a percentage of the shop cost, the cost of the product ready for sale. Therefore commercial expenses Ce should be distributed as a percentage of shop cost, $L+M+Me$.

Axiom 9 The normal basis for distributing commercial expenses is shop cost.

13 When the product is simple and homogeneous, for example, such as pig iron or cotton cloth, one account may suffice for all manufacturing expenses and one other for all commercial expenses, but when it is diverse or complex each of these should be sub-divided into one for each department or for each distinct class of product. In effect such a business is an aggregate of several businesses, some of which may yield better results than others, or may fluctuate more widely, and a proper accounting system should show the results of each sub-division or department separately, as well as the combined result of all. Hence arises in many cases great complexity in cost accounting, and corresponding need and opportunity for the skilled industrial accountant.

Axiom 10 An accounting system should show results both by departments and by totals.

14 In some cases the entire product consists of a single staple article, or group of articles, for which there is a constant demand and, at some price, a sure sale, such as pig iron, window glass, cotton cloth, etc. In other cases the product must conform to the specifications of the customer, and therefore cannot be made up in advance of orders, as in shipbuilding, carbuilding and the construction of buildings. The former is commonly designated as a

stock product, and the latter as contract work. The difference between these may be expressed as follows viz.:

A stock product is one which is made first and sold afterwards.

A contract product is one which is sold first and made afterwards.

Cost accounting is usually more complex and difficult in the case of contract work than in that of a staple or stock product.

Axiom 11 A contract product may require a more complex accounting system than a stock product for the accurate determination of costs.

15 The expenses of general administration overlap the manufacturing and the commercial divisions of an industrial business. Many items can and should be definitely charged to one or the other. Others may arbitrarily be apportioned between them; as, for example, the salary of an official who devotes say 70 per cent of his time to one and 30 per cent to the other. All others must be aggregated into groups for distribution by the methods adopted, as above, for distributing such expenses; as, for example, by percentages of productive labor or of shop costs. Expenditures of this kind are infinite in size, kind and number, and call for great skill and good judgment in their classification, which should be determined in advance by a clearly defined code, not left for haphazard decision by subordinates. Such a code, based on intimate knowledge of the business, on a clear perception of the information of the code is designed to yield, and on sound accounting principles, is an indispensable prerequisite to the accurate determination of costs, and equally to the intelligent conduct of any manufacturing business.

Axiom 12 An accounting system should be embodied in a code of instructions, for the guidance of those responsible for its operation.

16 For best convenience a code should provide symbols to represent the various accounts and their many combinations. For this purpose the writer for many years has used a system of letters and numbers which possesses great convenience. Letters are used to designate important departments and accounts, the significance of each letter depending on its place, as in decimal notation, in the symbol. Thus, the first letter may indicate a department, the second a sub-division of it, and the third a room or smaller unit. Stated numbers are used to indicate accounts relating to expenses of the

various kinds or groups. Such a symbol is shown by the following example, viz.:

BAC 10

in which *B* represents the department, or the class of product, against which the item is to be charged; *A* the shop in which the work is done; *C* the job, or machine, by which it is done; and 10 the kind of expense to which the charge relates, such as repairs of the machine, foreman's wages, etc. These symbols, and an explanation of their meaning and use are printed in a small book of pocket size, copies of which are furnished to all concerned. In this way a correct classification of every charge is made at the time of original entry, after which tabulation and aggregation of original charges follow automatically in accordance with the predetermined plan.

Axiom 13 Symbols are better than titles for recording charges in an extensive accounting system.

17 In any business certain expenses or losses occur from time to time which are unusual or abnormal. These may be termed "extraordinary expenses," and require special consideration. As examples of these may be cited a serious loss by fire, a curtailment of product by a strike, an abnormal loss through bad debts, an increase or decrease in value of land, etc. The loss, or profit, thus arising must of course be covered into the treasury, but this may better be done through a debit or credit to the surplus account than through a charge to the profit and loss account of the current year, for the latter plan would distort the statistical record of the year by including in it items not common to normal years. The best plan is to charge to the account of each year only the items which are normal, and to charge those which are abnormal to the surplus account. The proper purpose of the annual account is twofold, (*a*) to show the results of the year's operations, and (*b*) to contrast these results with those of preceding and succeeding years. On the other hand, all extraordinary gains or losses must be accounted for, and this may best be done through the surplus account. In this way both purposes are accomplished.

Axiom 14 Extraordinary gains or losses, in order not to distort the statistical value of the annual profit and loss record, should be covered into the surplus account between the closing of the books for the old year and the opening of the books for the new year.

18 Interest on borrowed capital is a distribution of profits, not

an expense, although often erroneously treated as the latter. To illustrate this suppose the case of two manufacturers, *A* and *B*, each having $200,000 invested in his business and each realizing 10 per cent, or $20,000, net profit available for dividends on a year's business, all of *A*'s capital being contributed in cash, while *B* has only $100,000 of cash capital, and another $100,000 of borrowed capital, on which he pays 5 per cent interest. At the close of the year *A* is in position to pay $20,000 in dividends to his stockholders, a 10 per cent return on their investment, but *B*, after paying $5000 as interest, is in position to pay $15,000 in dividends to his stockholders, a 15 per cent return on their investment. Evidently the actual profits from the operations of the year are the same in each case, only the ownership of the capital invested and the distribution of the profits being different. The accounting system should show the actual profit realized, regardless of its distribution to the owners of the capital invested in the business. On the other hand it is expedient that interest on temporary loans, and on time purchases if availed of, rebates and discounts of customers' notes, should be treated as current expenses, normal to the conduct of the business. In like manner discounts earned by cash payments should be treated collectively as part of the current earnings of the year, or else be covered into the net costs of purchases.

Axiom 15 Interest on borrowed capital should not be treated as an operating expense, but should be charged direct to the profit and loss account of the year.

19 Interest on all capital invested in a business may or may not be deducted before stating the final profits of the year. Here no principle is involved, but merely convention or individual preference. Usage, however, has practically determined that it shall not be deducted; that the final, or net, profit should indicate the return on capital, the amount which capital has earned. Stated thus it can readily be compared with what the same capital would earn if invested otherwise; as, for example, in government or railroad bonds, in mortgages, etc. If interest is deducted at all, as is done, for example, under some profit-sharing plans before allotting anything to the beneficiaries of the plan, it should be computed on the total capital invested in the business, including therein the surplus account; that is, surplus profits of previous years retained in the business and invested in plant or merchandise.

Axiom 16 Final profits properly signify the amount earned by

the capital invested. If interest on capital is deducted this fact should be stated, and interest should be computed on the total capital employed.

20 Where a business is divided into several or many departments it is very desirable that the accounting system should show the profits or earnings of each of them separately, and this is usually feasible, except as to annual depreciations and as to interest charges. In some cases either or both of these items can accurately be distributed among the several departments, and if so, they should be so treated. Where they cannot be so distributed they should be deducted in a lump from the sum of departmental profits, and in this case it becomes convenient to adopt terms to designate clearly the profit account at its various stages. For this purpose the writer has found the following terms satisfactory:

Gross profits: the aggregate profits of all departments, prior to deducting depreciations and interest.

Net earnings: the gross profits after deducting depreciations.

Net profits: the net earnings after deducting interest on borrowed capital.

21 In comparing the results realized in two or more comparable concerns or businesses it is essential to contrast profits at the same stage in each case, and to employ terms which are mutually understood as to their precise meanings. No standard as to these terms has yet been established. The proper basis of comparison usually is that indicated above by the term net earnings, which eliminates the variations due to the employment or non-employment of borrowed capital.

Axiom 17 Terms used to designate profits should indicate clearly the stage of profits to which they refer, and should be mutually understood.

22 Inventory valuations are an important factor in determining profits. Usually an actual inventory is taken only once a year. The merchandise inventory includes raw materials, stock in process, finished goods, and general supplies. A standard basis of valuation for each of these groups should be adopted and maintained from year to year. Raw materials, such as pig iron, raw sugar, baled cotton, ingot copper, etc., are often subject to wide fluctuations in market values or costs, and the question thus arises as to the proper inventory valuation of them, whether at cost, at market value at date of inventory, or on some arbitrary basis. If the effect of such

fluctuations is negligible, that is, is small in ratio to the annual total of the account, either of the first two methods above stated may be used. If the fluctuations are large, however, either in range or in their effect on the annual total, that is, if they materially influence the profit and loss account of the year, some arbitrary plan of accounting for them should be adopted. In devising this, the twofold purpose of the annual account, the operative and the statistical, should be kept in view. If the effect of the fluctuations is moderate in its ratio to the annual account a sound method consists in taking the mean, either of market prices or of actual purchase prices for say three or five years, as the basis for inventory valuations, and also for use in the compilation of costs, thus conforming to the average trend of market values but avoiding frequent and temporary changes. If, however, the effect of these fluctuations is serious or vital in determining the results of the business, a new factor is brought into the accounting problem, namely that of trading or speculating on the market. In the case of a sugar refinery or a cotton mill, for example, large profits or losses may result from market changes in the price of raw sugar or of baled cotton, or from the operations of the purchasing department. Obviously such gains and losses are totally unrelated to the economy and efficiency of the productive department, and to include them in its accounting might so distort it as to destroy its usefulness and its statistical value. In such cases a separate trading account should be established, through which to ascertain the profit or loss of the year in operating on the market for the raw material, the latter being charged to the manufacturing department at a constant price, conformed from time to time to average market conditions, this price being used also for inventory and cost purposes. In other words, the results of speculation on the market, however legitimate or necessary, should be segregated from the results of the normal operations of the plant.

Axiom 18 Speculative profits and losses should be segregated from those due to the normal operations of a business.

23 The inventory valuation of stock in process, that is, of stock in a partly manufactured condition, should be such as to cover the prime cost of the material, and of the productive labor already expended upon it, plus a ratable charge for manufacturing expenses. The inventory valuation of finished stock, that is, of stock completed ready for sale, should be on the basis of shop cost, not of actual cost, because the latter includes the cost of selling, and this has not

yet been incurred. A paradox, apparent but not real, is created when the cost of a product is substantially reduced, because thereby the inventory value, and therefore the profit of the year, is reduced. If the inventory value at the beginning of the year were $1000, and if during the year the cost were reduced 10 per cent, obviously, if the quantity on hand at the close of the year were the same, the inventory value would be $900, thus showing a shrinkage of $100. In the following year, however, this apparent loss would be converted into an actual profit.

Axiom 19 A reduction in cost implies a corresponding reduction in inventory.

24 The annual inventory may properly include as assets certain items previously classified as expenses. One example of this kind is the premium on unexpired insurance. Another is the cost of a trade catalogue intended to serve say for five years. To charge the whole of important expenditures of this kind into the current expense account of the year in which they are incurred would tend to distort its statistical accuracy, and hence would be bad accounting. The proper treatment of such expenses is to determine the period they apply to, and to charge off a proportionate part in each month or year during that period, carrying the remainder in the inventory.

Axiom 20 Expenditures in one year which cover the requirements of several years should be distributed over the years to which they fairly apply.

25 The inventory valuation of all property other than merchandise should be on the basis of its fair value in the business as that of a going concern, which usually is the cost to replace, with due allowance for wear and tear. An annual inventory of all property, by actual enumeration and count, is indispensable to the proper conduct of any manufacturing business, and in some cases more frequent inventories of the merchandise stock are expedient. Without such annual inventories no determination of annual results is reliable or of much value.

Axiom 21 An annual inventory of all property is indispensable to accurate knowledge and to good management.

26 The question of depreciation of fixed property enters into all industrial accounting, and should be treated in connection with the inventory. In this, as in all discretionary matters of accounting, the aim should be to find and follow the median line, the mean between ultra-conservatism and radicalism. All fixed property, ex-

cepting land, depreciates and tends to become obsolete. Normal repairs and maintenance should of course be charged to current operating expenses, not added to cost or value, and these should fairly be considered in fixing the ratio of depreciation. Where a building or a machine is maintained in perfect condition obviously it depreciates more slowly than one which is neglected. A building may be so maintained as to depreciate little or not at all. The proper rate of depreciation for each class or kind of fixed property is a matter of good judgment, for which no rules can be laid down. It may be as low as 1 per cent per annum, and in exceptional cases may be as high as 20 per cent. Usually it ranges from 2½ to 10 per cent. When profits are abnormally large the allowance for depreciation may wisely be larger than when they are merely normal, but the normal allowance should be made even when no profit is realized. Under average conditions it usually ranges between 10 and 15 per cent of the annual profits. A revaluation of all fixed property by outside experts or appraisers, at intervals of five or ten years, is expedient and usually worth its cost. Abnormal increases or decreases in the value of such property, as for example an increase in the value of land, or the loss due to the demolition of an obsolete building, should be covered into the surplus account, not into the profit and loss account of the year.

Axiom 22 Valuations of fixed property should be subject to annual review and to fair depreciation.

27 Finally, the aim and object of every accounting and cost system should be to afford true and accurate information as to facts. It is based on facts; it should embody and present facts, and naught else. To exaggerate facts and to show fictitious profits and values, is no worse than to depreciate facts and to conceal true profits and values.

Axiom 23 An accounting system should present facts, without bias in any direction.

28 Accounting, in its application to general business affairs, has long been a highly developed science, but is comparatively a new one in its specialized application to modern industry, with its vast and complex development. The creation of a *Correct Science of Industrial Accounting* and costs should be the desire and aim of all who are concerned with industrial management. To accomplish this, three things at least are needed:

a Clear understanding of fundamental principles

b Definite terminology, generally understood and accepted

c Free interchange of the data of practice, whereby the adoption of sound principles may be promoted, the experience of each may be available to all, the best methods may become established, and, above all, a standard system may ultimately be created.

29 The accomplishment of these results, by affording complete and accurate knowledge of the essential facts pertaining to industrial efficiency, and to the costs of production, will tend greatly and permanently to promote the development of American industry, and to aid it in securing its full share of the markets of the world.

THE POWER PLANTS OF TEXTILE MILLS

By John A. Stevens

ABSTRACT OF PAPER

This paper describes the purposes which should be served by power plants in textile mills.

It calls attention to the individuality of each plant and to the special design and adaptation necessary if it is best to serve its purpose, showing how manufacturing conditions as regards use of low-pressure steam in textile mills make well designed plants for such mills differ from those which would ordinarily be best and most economical for other lines of industry.

The degree to which power plants in textile mills are complicated by use of water power requiring relaying by steam units is discussed, and the effectiveness of electric transmission for securing necessary flexibility under these conditions pointed out.

Several power stations recently installed under the writer's supervision are described and illustrated, the purpose being to call attention to particular features of each plant which illustrate points mentioned in the paper.

A more careful consideration of the advantages which might be secured by groups of mill owners combining to produce power in a single station jointly owned and operated by the group is urged.

THE POWER PLANTS OF TEXTILE MILLS

By John A. Stevens, Lowell, Mass.

Member of the Society

The purpose of this paper is to place anew before those engaged in managing and operating textile mills some of the salient points which have to be considered in providing a power plant which shall do its best work in connection with such mills; and to show how the differing conditions make each plant a problem worthy of special consideration.

2 The power plant is apt to be regarded merely as an expense item and although this is only a small portion of the total of such items, usually not more than 3 to 5 per cent, it is so large a sum in dollars per year that possible savings therefrom possess a real interest for managers of textile plants and are receiving serious consideration whenever they can be properly presented.

DIRECT AND INDIRECT SAVINGS

3 The possible savings in connection with a textile power plant are at least of two kinds: (*a*) The direct savings brought about by producing through efficient apparatus a given quantity of needed power for a reduced expenditure of money after all expenses chargeable to power have been considered; and (*b*) the incidental savings realized through installing new equipment carefully arranged to meet the manufacturing needs of the plant, thus bringing about increased and more convenient and bettered production, or a decreased cost of manufacture. These frequently are of greater importance than the direct savings.

SPECIAL ADAPTATION REQUIRED

4 It is a fact so self-evident as hardly to need stating that in order to serve most perfectly all the requirements of a given plant and thus take advantage of all possible savings, its power

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equipment must be specially adapted to the individual plant, the conditions and requirements of which are never twice alike.

5 Textile plants, of course, can be roughly grouped into classes depending upon the kind of goods which they produce, whether worsteds and woolens, cottons, linens or silks; whether they produce yarns or cloth; whether their product is plain or colored; to what degree this product is finished and by what processes, that is, whether there are dye houses and bleach houses as part of the equipment, requiring large quantities of manufacturing steam.

6 Certain features of their power house design will probably depend, to a considerable extent, upon which of these groups they belong to, but the fact that there cannot be a standard design for a power plant, for any purpose, whether for public service, textile mill or other use, furnishes the real reason for the existence of the power plant engineer.

CONDITIONS MET WITH IN CENTRAL STATIONS

7 While the conditions and elements which make for diversity in design or most desirable equipment of central stations for public service corporations are everywhere admitted to be great enough to necessitate the careful working out of all features by a competent group of engineers, such equipment, when of small size, is generally much more capable of standardization than is that of the textile plant. In the great majority of cases the public service station has to do solely with the furnishing of electric energy for use by its customers in the form of power and lighting. It has, of course, no use for low-pressure steam in considerable quantities and its requirements for heating steam are insignificant.

8 In fact, so far as the question of low-pressure steam enters at all into its scheme of operation, it is rather one of avoidance than otherwise. Its problem is to see that no more is produced at any time than can be made use of for the purpose of heating feedwater, and anything beyond this quantity is an absolute waste.

9 The influence of this condition extends so far that not infrequently it has led such plants to forego the savings from an economizer, because if such a unit were used economically, there would be so little remaining use for exhaust steam that auxiliaries, which for reasons of dependability and flexibility

it has seemed best to keep as non-condensing steam units, would be exhausting to atmosphere.

10 The public service station manager is thus prevented from the possibility of realizing in his own plant large savings from conditions which can be obtained by the manager of the textile plant, savings, too, which must be thus taken advantage of if the item of total coal cost in that plant is to be kept at minimum.

11 This absolute dissimilarity of conditions goes far to explain why it has sometimes happened that engineers and power sales agents who have received their training mainly in situations where there was no possible use for low-pressure steam, have utterly failed to realize the extent of savings which may accompany such use. They have sometimes gone so far as to cause the abandoning of steam-using machinery and the purchase of current for power, even in plants containing dye houses, with the result that the total bill for power and manufacturing steam was thereby increased very nearly to the extent of the power bill. This, of course, represents an extreme case, and is mentioned here merely as a means of bringing out clearly the extent to which conditions may sometimes influence the proper solution of a textile power plant problem.

COMBINED POWER AND MANUFACTURING STEAM USING UNITS

12 The plant which can obtain power from units properly combined with the supplying of steam for necessary manufacturing or heating processes has open to it possibilities for securing the same at costs far below those available to others not thus fortunately circumstanced.

13 The reasons why, when conditions are suitable, such considerable savings can be realized by making the power producing unit practically a reducing valve for the manufacturing steam line, or looked at from the other point of view taking the manufacturing steam from the power line as a sort of byproduct, are well understood by all engineers who have had occasion to consider the matter.

14 Although the practice is old, dating back many years, we still find men occasionally who feel that the idea of getting the work required from an engine and from a dye tub with less coal when the latter takes its steam through the engine than when both are supplied by separate lines from the boiler is a

sort of perpetual motion scheme—a producing of something from nothing.

15 They fail to take into consideration that there is a tremendous amount of heat energy rejected through the condenser even by the most efficient engine or turbine, while the dye tub is particularly well fitted to make use of this very energy which the engine or turbine cannot use. On the other hand, the dye tub cannot as efficiently utilize the energy from the high-pressure end of the range and from which, in the combined unit, power is obtained.

16 When the steam turbine first began to replace the steam engine, it generally was not designed to meet this condition of furnishing low-pressure steam and the fact that it was better able to use steam efficiently through the high vacuum ranges doubtless led to the feeling that it was not so well adapted as the steam engine for supplying steam for manufacturing purposes.

17 Later experience has shown the fallacy of such belief and now turbines are designed with special reference to such uses. It is also worth noting that at any given pressure steam leaves the turbine considerably dryer than it leaves the engine.

18 The quantity of manufacturing steam required and the regularity of demand for the same varies greatly in different mills. For best results individual conditions should receive careful study before equipment is chosen. Where demands are large and constant non-condensing units may offer the best solution. Where demands are extremely variable some system of bleeding a portion of the steam from the receiver or stage of a condensing unit is more practicable.

USE OF CONDENSING WATER DISCHARGE IN TEXTILE PLANTS

19 It sometimes happens that power producing and manufacturing machinery can be very advantageously combined in another way. When there is a large and constant demand for warm water to be used by textile machines, the cooling water from condensers, carrying with it the rejected and otherwise waste heat from steam, can be taken to these manufacturing uses where, unless this were done, cold water would have to be used and heated by steam for which coal would be especially burned. Thus put to work the condensing water may save a portion or all of the above-mentioned coal, depending upon the temperature of water required.

20 The drawbacks to this scheme which prevent its more frequent use are that the demand is apt to be for a relatively small amount of water at a considerably high temperature, while the supply from a normal and efficient working condenser would be that of a larger quantity of water at a temperature only moderately in excess of that of the cold water supply. Again the steam engine, which can better stand a rather low vacuum than can the steam turbine, under this condition requires the use of a surface condenser in order to avoid the presence of even a small quantity of oil which usually is objectionable.

CONDITIONS COMPLICATED BY USE OF WATER POWER

21 It is believed that the power plant situation of a textile mill is, more frequently than with any other type of plant, complicated by the presence of water power equipment developed to such an extent that a considerable portion of it requires relaying with some form of coal consuming units. This is especially true in those sections where the textile industry had its beginning and earlier growth, and has come about naturally from the fact that the textile industries are among the oldest of considerable importance in the country. There are many great textile corporations whose history goes well back towards the beginning of the last century, or at least to a time when water privileges could be more readily obtained than is the case today, and when steam power was but little developed and relatively inefficient. Water power developments of great extent and cost were made during those early days, the rights in which are still held by the original textile companies or by their successors, and which practically make financially necessary and good policy the continued use of water power to an extent which would be prohibitive were the developments being made from the beginning today.

22 Other industries and especially public service corporations, being of later growth, missed the opportunity to share in the rights of these early water power developments; or when they secured water privileges, have in the main because of expense, developed them less fully. Their equipment in any event is more likely to be modern and thus fit in better with present-day power-generating machinery.

THE NEW POWER PLANT DEVELOPMENT

23 The problems of textile power plants can be subdivided into two classes: (*a*) entirely new developments, and (*b*) those which have to do with changes or further developments in an existing plant.

24 When an entirely new power plant is under consideration, the fundamental points are the same whether it be for a textile mill or any other purpose. These are accessibility to railroad or barge for handling coal and ashes, coal storage, boiler feed and condensing water supply, also convenience of and ample space for future expansion of plant.

25 *Importance of Track Facilities.* The importance of laying out a new manufacturing plant or making additions to an old one to secure the best, or at least workable, track facilities cannot be too strongly emphasized. The point is so old and so fundamental, so well-known to all engineers and plant managers, that the writer would hesitate to mention it had he not found in actual practice that it is frequently overlooked or given too little consideration.

26 With the rapid increase in size and weight of rolling stock, the railroads of the country have found it necessary to increase greatly the minimum radius of curves over which they will undertake to handle cars, with the result that where the small cars of a decade ago got around with no serious inconvenience, the large equipment of today too often can not go. The manufacturer who builds an important mill group without first having his track connections definitely laid out to the approval of railroad engineers, is apt to find that intended connections are impossible, or at least awkward and unduly expensive.

27 *Providing Room for Future Development.* The importance of locating a new power house to have ample room for growth, is another point which ought not to require mention, but the fact that rapidly growing plants are so frequently found with this important portion of their equipment needlessly built into a hole, seems to justify some mention of the subject.

28 Sometimes such building is forced upon a concern by the circumstances of location and business conditions, and it is then of course justifiable as it has been done with full recognition of the fact that it is going to prove expensive later on. The

greater portion, however, of such building seems to have come about through a lack of conception that there were possibilities of greater things in the future and through an unwisely directed effort to economize in the first cost of power equipment, an effort which not infrequently has failed in itself since as much has been spent in the location impossible of further development as would have been required to meet the existing demands and still provide the possibility of further needed growth.

29 The serious feature of building a power plant in a cramped location lies in the fact that if the growth of the manufacturing is such that more power is required, it is almost impossible to remedy the condition. The existing plant represents a heavy investment in equipment which should be good for many years more service. To move it to a location where expansion can take place, or to abandon it and substitute new equipment means, in the latter case, a fixed cost for the new station well nigh or absolutely prohibitive; to build another independent equipment to meet new demands and let the old remain, means continuous operating expenses much higher than should be secured with a single station. The providing of ample facilities for growth if undertaken at the proper time is usually so simple and comparatively inexpensive that this feature should never be neglected.

30 *Location with Relation to Future Manufacturing Growth.* Another point frequently overlooked in locating a power house is that it shall not be in the way of future development of the manufacturing buildings. It often happens that some department must be enlarged, but the power plant is in the way. As the latter usually cannot be moved, the addition to the manufacturing department must be put somewhere else, disrupting the organization of the factory and breaking the proper passage of the product from raw stock to finished goods. This results in increased handling and trucking, and increases the cost of the finished product.

OLD POWER PLANT DEVELOPMENT REQUIRING ADDITIONS

31 The subject of the second subdivisions, viz., problems which have to do with changes or further development in an existing plant, of necessity make up the greater portion of the work of a power plant engineer.

32 *Power Plant Analysis a Method of Handling Preliminary*

Work. The method of attack, which, in the writer's own experience, has proved most satisfactory in getting at the requirements of these individual problems and so presenting them as to lead to well advised action on the part of plant managers, is by means of the plant analysis, a detailed study of and report upon that mill's whole power plant situation.

33 Through the gathering of data necessary for such a report, the engineers in charge of the work become better acquainted than in any other way with the resources, the possibilities and the requirements of that plant.

34 Such a report aims to show accurately the extent and value of present equipment; how much and where energy is produced and how distributed, with details as to quantities required for such subdivisions as frictional resistance, useful power and lighting, and steam and coal consumed for manufacturing and heating; also the cost of producing power with present equipment. These costs are compared with those which should result through installing other equipment in accordance with one of several schemes, preliminary plans and estimates for which are worked out. Such schemes are thus compared, the strong and weak points of each developed and as far as possible the whole question is reduced to a financial basis looking either towards the greatest return from the least new expenditure of money, or the greatest return when service-ability through a period of years and adaptability to plant conditions and growth are considered.

35 *Power Plant in Old Mill an Adaptation to Existing Conditions.* The power plant problem in an old textile mill is always one of adaptation not only to the requirements for power in all its phases, but more especially, as has previously been pointed out, to the more difficult requirements of having the new equipment fit in with that already in the plant and thus form a satisfactorily working unit at least expense, while still conserving as far as possible the money already expended.

36 The special lines along which adaptation has to be secured in any individual textile plant of course depend to a great degree upon the complexity of its power plant equipment and power uses, differing all the way between the comparatively simple condition of an all steam using plant burning coal for power uses only, and the plant making large use both of manu-

facturing steam taken from power producing units and of water wheel equipment requiring extensive relaying by steam.

37 The question of power plant location will of course be affected by the presence of one or all of these factors, for the grouping of this equipment, so that it can be handled with the fewest possible men, has a considerable effect on the final cost of power. If steam is to be used through engines or turbines for manufacturing purposes, it is very desirable that the location of the power house should be near that of these manufacturing uses, both to avoid drop of pressure in the large steam mains, and to keep the cost as low as possible.

38 *Electric Transmission as an Aid to Adaptation.* The development of electric transmission makes possible the gathering together of all steam power producing machinery in a single station under the charge of a comparatively small group of men and leaves the designer free to locate that station where it will have room for further development, be convenient for coal handling, and out of the way of manufacturing processes. It sets free for manufacturing use a considerable portion of space which was formerly taken up by belt towers and belt ways, main lineshafting, bevel gears, quarter turn and rope drives, all of which were heavy and extremely expensive both as to first cost and maintenance.

39 Above all it enables manufacturing buildings to be placed in any manner best suited to location and manufacturing conditions, and renders easy the changing and regrouping of machinery which in some departments of textile work is constantly going on owing to changed demands for production.

40 *Electric Transmission in Connection with Water Power.* By the installing of generators on waterwheels it gives this portion of power a flexibility which it has never before had and it thus somewhat simplifies the serious problem of relaying this power.

41 In many instances it is found possible to gain the necessary flexibility and prolong for a considerable time the useful life of old waterwheel equipment by means of installing belted generators connected to the main shafts of these old wheels. While this is not an efficient means of generating and transmitting power, the relatively small cost at which the necessary added equipment can frequently be installed, compared with that of an

entire new equipment of waterwheels and direct-connected generators, makes the real cost of power thus secured for the time being very attractive and retards the otherwise necessary expenditure of large sums of money.

PLANTS WHICH ILLUSTRATE THE POINTS MENTIONED

42 A brief description of several installations which have recently been made under the supervision of the writer's office

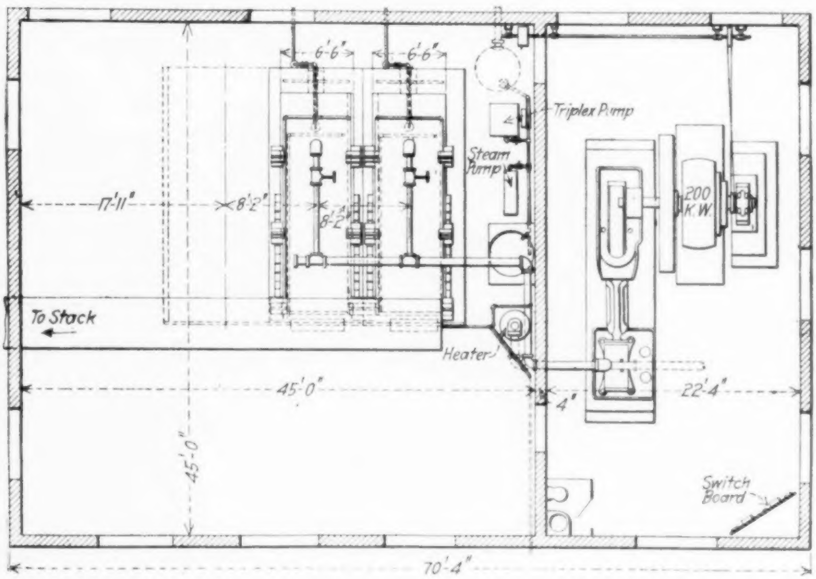

FIG. 1 PLAN VIEW OF POWER PLANT FOR THE BRISTOL MANUFACTURING COMPANY

serve to illustrate the working out of many of these points. Before beginning construction work on some of these plants which presented especially difficult points, the writer consulted freely with engineers who have had large experience and wishes to make acknowledgment of the courtesy and assistance received from them.

A SIMPLE DEVELOPMENT

43 Figs. 1 and 2 show the plan view and outside of the station of The Bristol Manufacturing Company, Bristol, Conn., to illustrate a small and very simple power development. This power house is wholly of monolithic reinforced concrete.

44 The station runs in conjunction with waterwheels and is situated in an irregular corner of the property between a public street and the railroad, and out of the way of valuable manufacturing space. It provides room for expansion of the power plant up to the limits of the possible development of the property.

44 The plant consists of horizontal return tubular boilers and a Cooper Corliss engine driving a direct-current generator. The

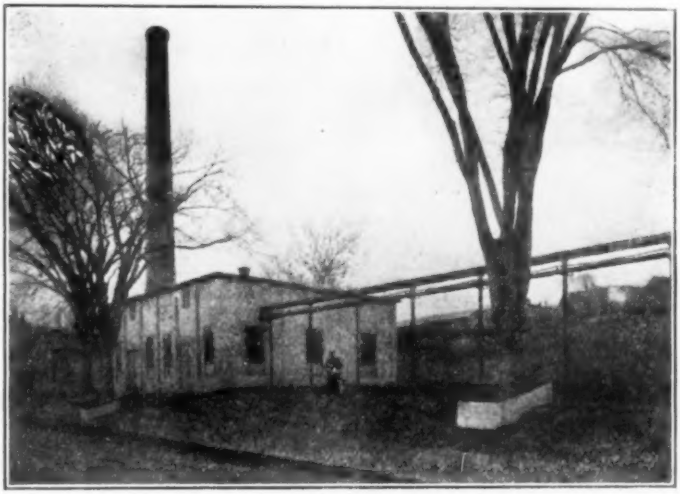

FIG. 2 OUTSIDE VIEW OF POWER PLANT OF BRISTOL MANUFACTURING COMPANY

power for the pumps and auxiliaries is taken direct from engine during running hours. The waterwheels are mechanically connected to mill drives and used to fullest extent possible at all times. The motors drive on to same main shafts and supply the varying make-up load.

45 Fig. 2 shows the simple system of supporting both manufacturing steam line and cables from wrought-iron columns in the mill yard.

A PLAIN GOODS COTTON MILL

46 An example of a simple station for a plain goods cotton mill is furnished by that of The Salmon Falls Manufacturing Company, Salmon Falls, N. H. (Figs. 3a and 3b).

47 Their need was for added steam equipment both to

furnish more power and to relay an extremely variable water power development. This was furnished by the building of a concrete and brick turbine house adjoining the old boiler house and installing a 750-kw, 3600-r.p.m. General Electric steam turbine, connected to a Westinghouse LeBlanc condenser. Arrangement was made for taking the heater make-up water for boiler-feed supply from the discharge of this condenser.

48 The turbine house is built with one temporary end, space being provided for extension both of turbine and boiler rooms.

49 The present boiler house situation was met by replacing old worn-out boilers with new Manning type boilers.

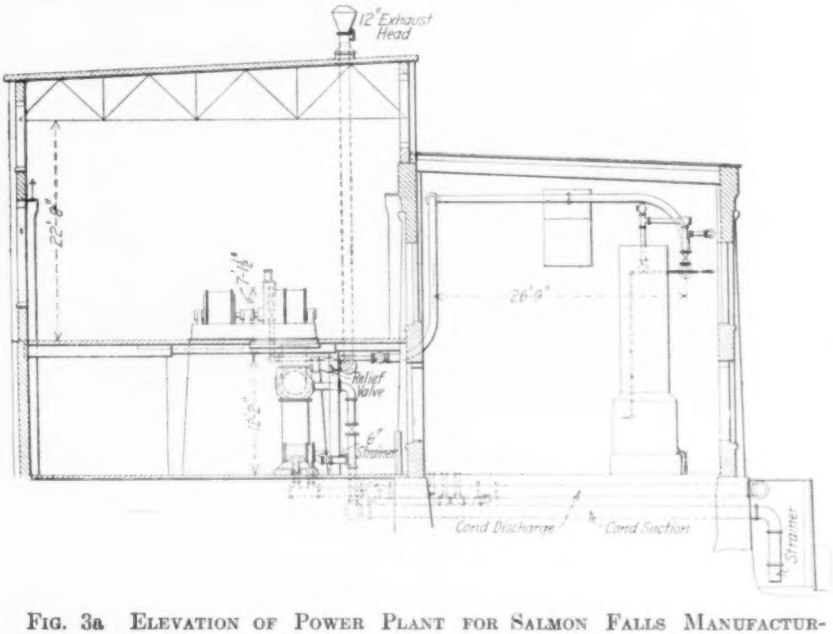

FIG. 3a ELEVATION OF POWER PLANT FOR SALMON FALLS MANUFACTURING COMPANY

50 The method of tying in with the old water power development which here proved most practicable was by installing rather large sized motors connecting to the main shafting groups, and when water gave out disconnecting from waterwheel by means of clutches, many of which were a part of the old equipment.

51 As a part of this development, the entire mill group was equipped with an electric lighting system consisting of tungsten lamps. These replaced gas lighting from a gas plant which

the owners themselves operated. By this change they secured more and better illumination and a more convenient source of light at reduced cost.

A REVISION OF WATER POWER DEVELOPMENT

52 A recently installed hydroelectric unit for the Merrimack Manufacturing Company, Lowell, Mass., serves well to illustrate certain conditions which frequently have to be met in connec-

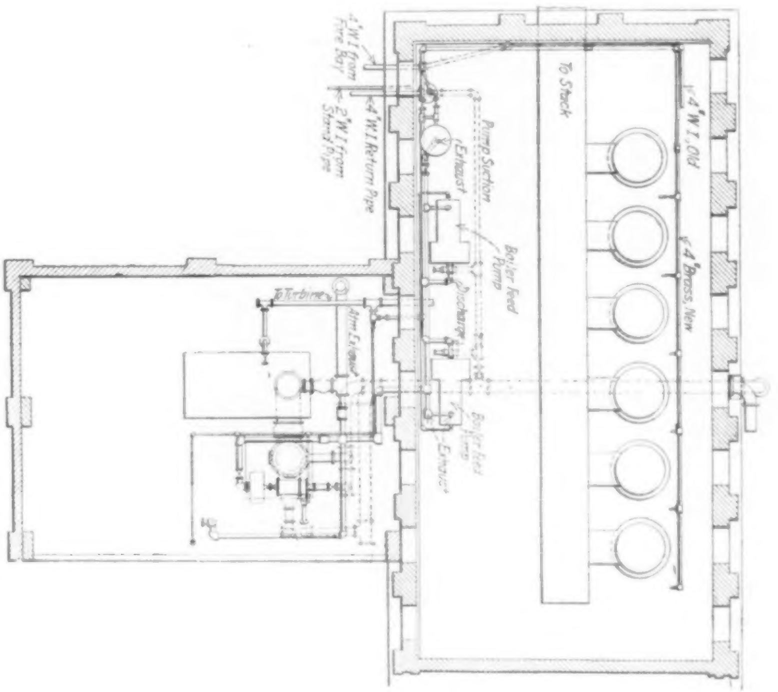

FIG. 3b PLAN OF POWER PLANT FOR SALMON FALLS MANUFACTURING COMPANY

tion with water power revision in an old textile mill when such becomes necessary.

53 A considerable portion of the power required for this group of mills had originally been furnished from Boyden wheels connected by bevel gears to systems of main lineshafts in mill basements. As is always the case with any water power development in that locality this requires extensive relaying with some form of coal burning units and had been provided by

means of steam engines geared or driving direct on to certain groups of this main shafting.

54 In order to provide power for one mill group situated on a higher level, there had been in service a line of inclined shafting some 220 ft. long driving through two sets of bevel gears from the extreme end of a main shaft about 700 ft. long, on which had been geared 5 waterwheels and to the other end of which a highly economical triple expansion vertical engine (Fig. 4) was direct-connected.

55 *Economical Direct Engine Drive.* This engine uses steam at pressures from 120 to 200 lb. per sq. in. according to load, and by repeated careful tests was found to have an economic range anywhere between 700 and 2000 i.h.p. and thus is well suited to the extreme variations in load which it has to meet, and exemplifies a simple and efficient means of relaying water power. The direct connection of engine to shaft, does away with transmission losses due to ropes or belts and the heavy up-keep on same. The engine might sometimes preferably be placed midway the length of shaft, but in this instance was placed at one end both better to conform to requirements as to available space and to make main high-pressure steam lines as short as possible.

56 *Waterwheel Equipment.* The waterwheels which had originally driven the picker building, and a portion of those on the main lineshaft, were entirely worn out, having been installed in the early 50's and in order to make use of water power required replacing by a new development.

57 Through improvements in the river bed, its average level had been lowered several feet leaving the wheel pits and tail races of these old wheels in a position where for much of the year they could not take advantage of the full available water fall.

58 There were already in service enough good wheels on good mechanical drives to absorb that portion of water power which can be depended upon at all times and does not require relaying.

59 *New Development Determined Upon.* While it is the writer's opinion that the more direct portions of these mechanical drives cannot be improved upon by any system of electric transmission, it was desirable in carrying out the new water-

wheel development to do away with the portions dependent upon much gearing and to provide for flexibility, so that this portion of power could be used where mill conditions should demand. To meet these requirements electric transmission again seemed to offer the best solution.

60 It was decided to drive the Picker Building by motor and the mill formerly driven by inclined shaft, and to make use of

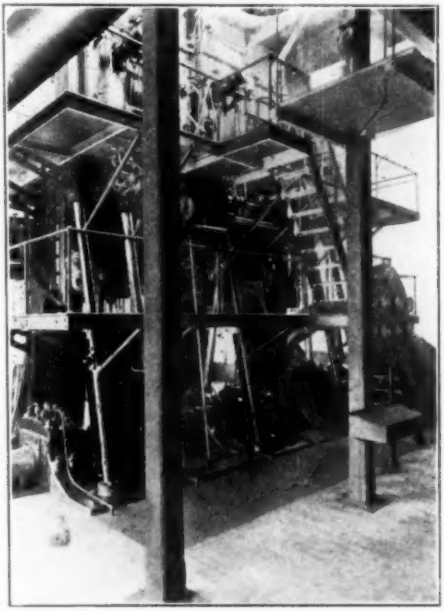

Fig. 4 Direct-Connected Triple-Expansion Steam Engine in Plant of Merrimack Manufacturing Company

the main feeder and tail race of one of the old wheels so far as possible in the new development. The basement of the old mill building was too low for a suitable generator room without interfering seriously with valuable mill space, and in any event the old main lineshaft could not be disturbed.

61 The original feeder from a point just inside the mill was extended and gradually enlarged from a diameter of 8 ft. to 12 ft., being carried down through the side of the old wheel pit, under the main shaft, then up and out through the mill wall

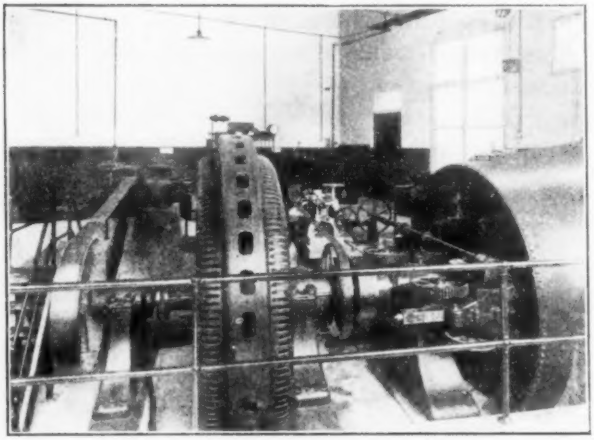

FIG. 5 INTERIOR OF WHEEL ROOM SHOWING WATERWHEEL AND GENERATOR AT MERRIMACK MANUFACTURING COMPANY

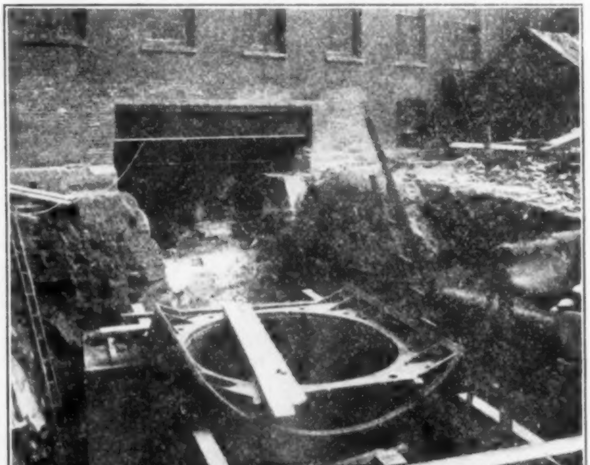

FIG. 6 VIEW OF SADDLE FOR DRAFT TUBE AND OPENING FOR MAIN FEEDER WATERWHEEL AT MERRIMACK MANUFACTURING COMPANY

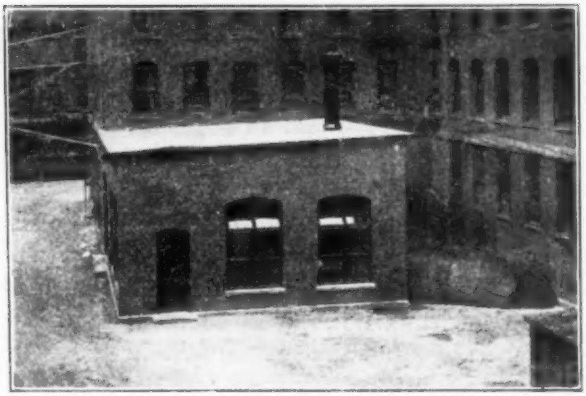

FIG. 7 EXTERIOR VIEW OF WHEEL HOUSE AT MERRIMACK MANUFACTURING COMPANY

FIG. 8 VIEW LOOKING INTO TAIL RACE OF WATERWHEEL AT MERRIMACK MANUFACTURING COMPANY, SHOWING CONCRETE LINING IN PORTION NEWLY CUT DOWN

and to the entrance of the wheel casing situated in a small independent building outside and apart from the main mill.

62 This wheel was so located as to have its draft tube discharged directly into the old tail race which was cut down for a depth of about 6 ft., its whole length, to the river. This cutting was in solid rock and the bottom and sides were made smooth with concrete (Fig. 8). In this way the full present fall from canal to river is made available and upon the test of wheel the losses through feeder and tail race were found to be small. The Holyoke Machine Company furnished the wheels which work normally under from 36 ft. to 39 ft. fall and run at 200 r.p.m. Current is furnished by a 1100 kv.a., 2300-volt 3-phase alternating current generator, and the greater portion is used on 2200-volt motors.

A STEAM TURBINE STATION FOR PLAIN GOODS COTTON MILL

63 A larger installation and one calling for considerable adaptation to local conditions is that of The Boott Mills, Lowell, Mass. This is a plain cotton goods mill doing neither bleaching nor dyeing and employing manufacturing steam only for slashing and a few minor uses.

64 A considerable portion of its power is at times furnished by nine old vertical waterwheels subdivided into four groups and located in the various mill buildings. The power thus available is not far from 3650 h.p. maximum, and 2920 normal, but decreases to between 1300 and 1400 h.p. during extreme dry weather periods, thus requiring extensive relaying. At the time when the new steam plant development was undertaken, power in addition to that of waterwheels and for the relaying of same was being furnished by two sets of old twin Corliss condensing engines and by an extensive purchase of current from a public service corporation.

65 The boiler equipment consisted of six B. & W. boilers of 305 normal h.p. each, all in good condition, and a good chimney 200 ft. high. The boilers and engines occupied the lower portion of one of the mill buildings. Serious shortage of power at times of low water made a large increase of steam equipment necessary.

66 The value of the existing boiler plant together with other local conditions made it seem advisable, after careful investiga-

tion, to retain the power plant practically in its old location.

67 *Possibilities of Low Pressure Turbine.* The possibility was considered of increasing the available power output by means of a low-pressure turbine taking steam from old engines but found impracticable because of the extremely advanced age and light construction of the engines. So far as the writer's experience goes this has proved to be the determining factor in a number of cases where this expedient has been considered. The engines in many textile mills are now very old, having served the full period generally allowed to constitute the useful life of such a machine and frequently are of much lighter construction than the best engines of a later date.

68 To install expensive new equipment dependent upon and forming a unit with such engines, does not seem justifiable, however desirable it might be were the engines and flywheel of thoroughly good construction. It was finally decided to abandon the manufacturing floors over the space originally occupied by the old engines, to wall off this portion, do away with one of these engines and to convert this space into the start of a modern steam turbine room.

69 *Special Conditions Requiring Adaptation.* Crossing diagonally under the end wall of the building and extending well under the space which must be occupied by steam turbines were the two tail races of one of the group of waterwheels, and the arches of these old tail races were not of particularly good construction or suitable to form portions of foundations for modern large sized units. Still further, in order to provide for the ultimate capacity of the plant desired by the owners, it was necessary to economize more than ordinarily in the use of room, as space available in this location was much cramped.

70 The solution of the whole problem which at once overcame all these difficulties was found by supporting the main generating units on a system of deep transverse girders whose columns were either carried directly to ledge rock or supported on other girders over the raceway and the supports of which were likewise carried to rock.

71 In this way a basement was secured giving only a small amount less room than that of the floor above and saving for other uses practically all the space usually occupied by foundations, but every inch of which will ultimately be needed for condensers, feed pumps, fan, engines and main piping.

72 The supporting of machines on girders made possible the placing of condensers directly under exhaust nozzles of steam turbines and in the case of the present LeBlanc condenser unit and one future unit, the connecting of condenser discharge through a water sealed pipe directly to tail race, thus considerably decreasing the work which condenser turbine has to do.

73 *The New Equipment.* The first unit of this group which is a General Electric steam turbine of 3244 kw. capacity at 80 per cent power factor, running at 1800 r.p.m. and generating 3-phase 60-cycle current at 600 volts, has now been in service about a year and a half, and has been running constantly in a thoroughly satisfactory manner with no trouble from vibrations or other causes. This is illustrated in Fig. 9 and is specially mentioned because so far as the writer knows this is the first instance where a large machine has been supported by transverse girders. There are several earlier instances where machines of other makes and of large size have been supported by longitudinal girders.

74 The question of securing needed additional boiler capacity has been solved for the present by installing an induced draft fan and economizer, the engine which drives the fan being placed in the basement under the main turbine room floor (Fig. 10) together with the boiler feed pumps, thus grouping all auxiliaries together where they are away from the dust and dirt of the boiler room and under the constant observation of the turbine room attendant.

75 The drips from heating systems in winter and from slashers at all times are returned to a small open heater to which fan engine and condenser turbine exhaust. Water is taken from this reservoir to economizer usually at about 90 to 100 deg. temperature, thus leaving an ample range through which the economizer can and does work.

76 The whole equipment thus forms a compact unit and even with the light loading which at times results from the steam turbine being in part a relay to the waterwheel equipment, the over-all economy of this steam group has been excellent.

77 A connection for stage extraction of steam for use in mill heating is provided on this machine, and the piping connections necessary in the station are already completed, but as the revision of heating system throughout the mills has not as yet been made, this has not been used.

STEAM TURBINE ISOLATED STATION

78 A power plant recently built for the West Point Manufacturing Company, Langdale, Ala., furnishes an example of a

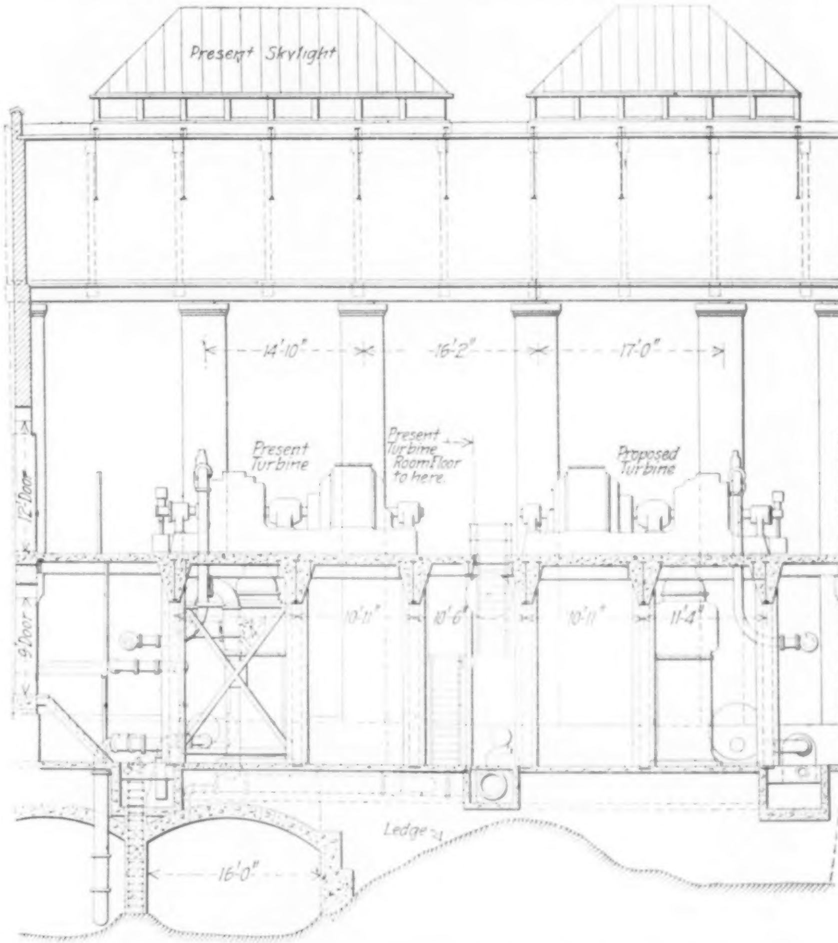

Fig. 9 Sectional Side Elevation of Turbine Room for Boott Mills, showing Support of Turbine by Girders

complete new development, situated out of the way of and apart from manufacturing buildings and with unlimited space for expansion to meet possible requirements of a series of mill groups. The primary purpose of this development was to furnish a relay to a water power development.

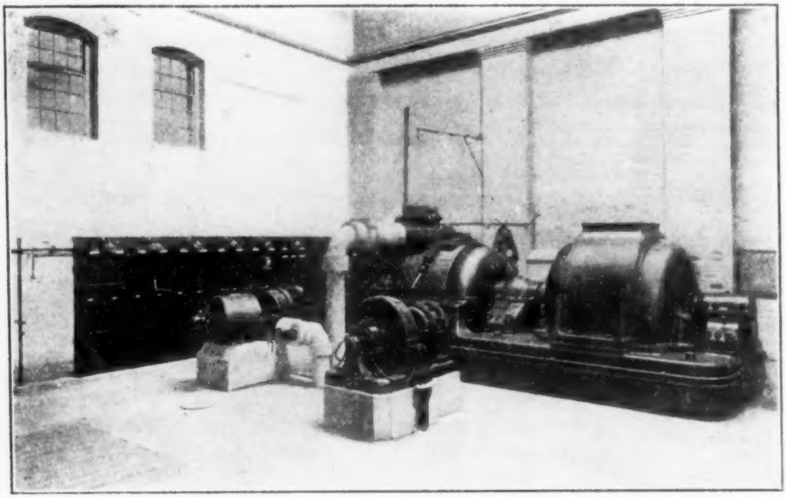

Fig. 10 Interior View of Main Floor of Turbine Room at Boott Mills

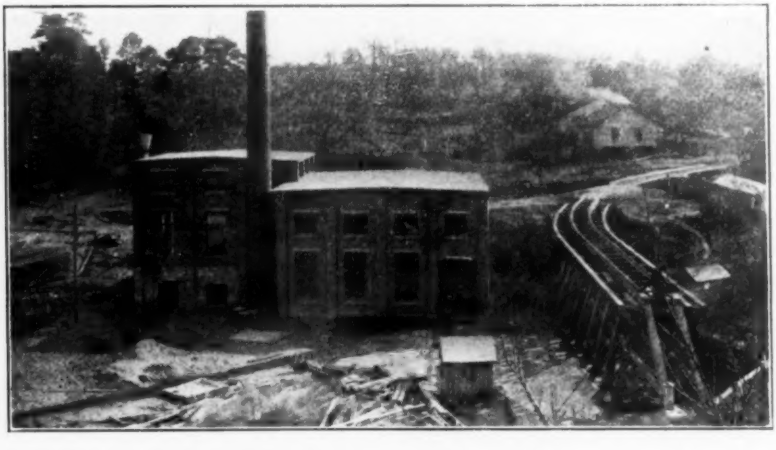

Fig. 11 Outside View of Turbine and Boiler House for West Point Manufacturing Company, Langdale, Ala.

79 The old power plant at this group was so situated as to have very limited coal-handling facilities and no room for further extension, while the new location chosen (Fig. 11) is in a natural amphitheater which offers ready means for handling and storing large quantities of coal by merely dumping from a trestle.

80 There is also an unlimited supply of condensing water close at hand. This is taken from discharge of waterwheels and furnishes an element which is lacking or difficult of access at some of the other mill groups. These two combined advantages of location thus make this the natural point for the start of a central station.

81 The unit first installed consisted of two 308-h.p. Heine boilers and a 750-kw. General Electric Company 3600-r.p.m. 2-stage steam turbine connected to a LeBlanc condenser and with generator for 600 volts. As there was good prospect of growth in the immediate future, the boiler house was built large enough for five units and the turbine room (Fig. 12) made sufficient in size for one additional larger unit. The three extra boilers and a 2000-kw. steam turbine are now in process of erection in these spaces, as is also a permanent brick chimney to replace the temporary steel stack which served the first installation.

LARGE PLANT PRODUCING CARPETS AND CARPET YARNS AND HAVING EXTENSIVE DYE HOUSES

82 An installation on which an exceptional number of special problems had to be met was that of the Bigelow Carpet Company in Lowell, Mass., a large corporation engaged in the manufacture of carpet yarns and carpets.

83 This company has extensive dye houses which make a more than ordinarily constant demand for large quantities of low-pressure steam, a portion of which had been furnished by the exhaust from old engines.

84 The irregular grouping of buildings in this plant made any form of mechanical transmission of power particularly difficult and resulted in many complicated drives and heavy friction losses. The plant is situated in the heart of the city where land values are high and a desirable vacant space for a power station was lacking.

85 A portion of its power was being obtained from three

vertical waterwheels, two being in one group, all situated in mill basements and all very old.

86 *Most Advantageous Position for New Station as Schemed by Analysis.* In the power plant analysis which had preceded the undertaking of this development, the many advantages of a combined steam turbine and hydroelectric station located on the space then occupied by the small mill building, in whose

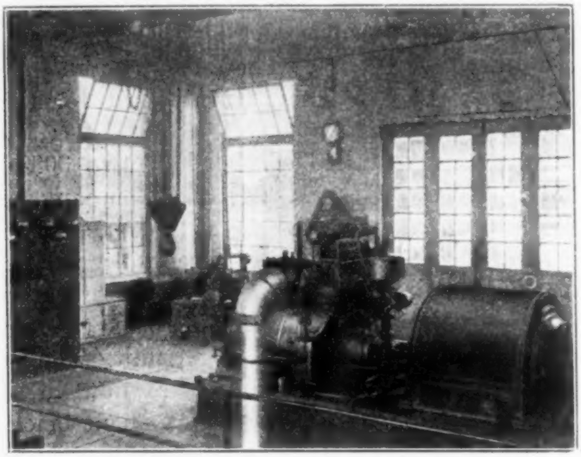

FIG. 12 STEAM TURBINE ROOM, WEST POINT MANUFACTURING COMPANY

basement the two old waterwheels were situated, had been pointed out.

87 A system of concrete feeders extending from the main canal to within a few feet of this building had been installed only recently at considerable expense. This building was also located in close proximity to new dye houses then under construction, where large quantities of low-pressure steam would be required. By abandoning the three old waterwheels and making all new development in one location, the old single feeder became an excellent underground tunnel for pipes and electric cables.

88 This tunnel was available in part for a passageway to and a means of getting steam from boiler house to turbine house and throughout as a means both of distributing electric current, and furnished space for a water pipe line from feeder to dye house. The old wheel pit too, became available at small

expense as a much needed central low point to which all plant steam returns could be drained and thence pumped to the boiler house.

89 It was decided to demolish the old building and in its place build one which would accommodate a complete new waterwheel equipment with groups of wheels direct-connected to electric generators, a steam turbine station for present and all anticipated future development and besides provide above the section used for power station, two floors of manufacturing space. This manufacturing space is occupied by picker machinery. The floors match those of adjoining mill building and afford communication to other groups.

90 *Description of New Building and Power Plant Equipment.* One corner of the rectangle otherwise available was taken up by the stair tower of an adjoining mill and in the remaining space switchboard galleries and exciters were located.

91 As shown in Figs. 13-17, the main turbine room floor is situated directly over the waterwheels which are placed in concrete waterways with foundations extending down to bed rock.

92 The waterwheel generators are accommodated in a small space at the far end of the building, and at an elevation corresponding to that of the bottom of the waterways.

93 This portion of work, up to and including the turbine room floor, is of reinforced concrete and was so designed and built that steam turbine units of much greater size than those now required can be placed anywhere in the space as may be desired.

94 The present steam turbine equipment consists of three 750-kw. General Electric units especially designed with top exhausts and capable of being run either condensing in the ordinary way or non-condensing against a back pressure of 6 to 10 lb. These turbines are connected in groups of two with Westinghouse LeBlanc condensers, the space for the fourth turbine unit as yet being vacant.

95 Water for those condensers is taken from the middle waterwheel feeder and after doing its work in condensers, is returned to the feeder where it is later used through waterwheels, so that there is thus no extra use of water for condensing purposes.

96 The steam connections to condensers are controlled by

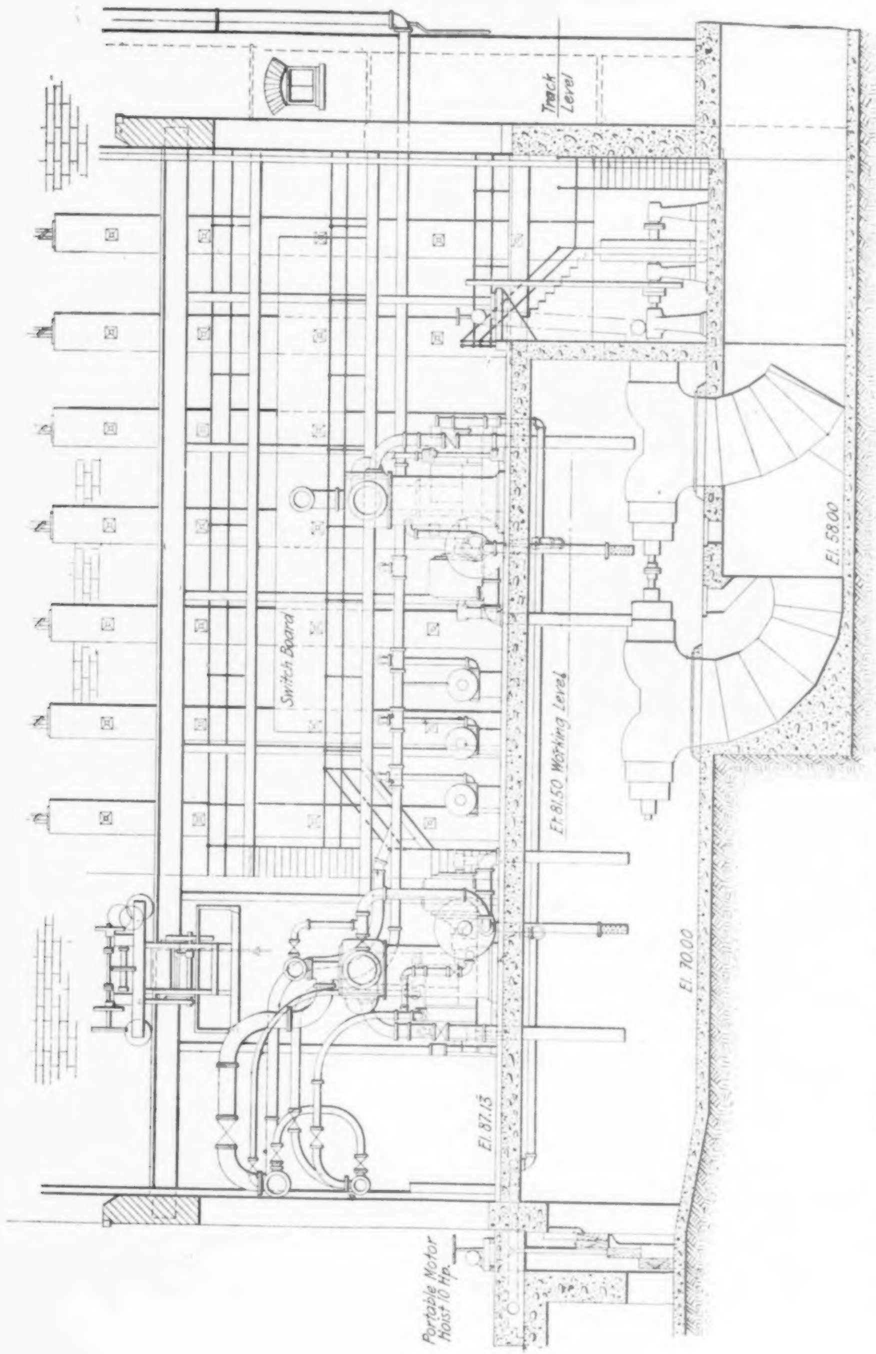

FIG. 13 SECTIONAL SIDE ELEVATION OF COMBINED STEAM TURBINE AND HYDROELECTRIC STATION, BIGELOW CARPET COMPANY

motor-operated gate valves. Besides the connection to condenser, the exhausts of two of these turbines are also connected to a 20-in. low-pressure steam line leading to the dye house and the low-pressure piping system of the plant.

97 All steam-driven auxiliaries in this station were designed to run against a back pressure and are connected to the low-pressure main. Additional connections are provided for the condenser turbines so that they may exhaust direct to the con-

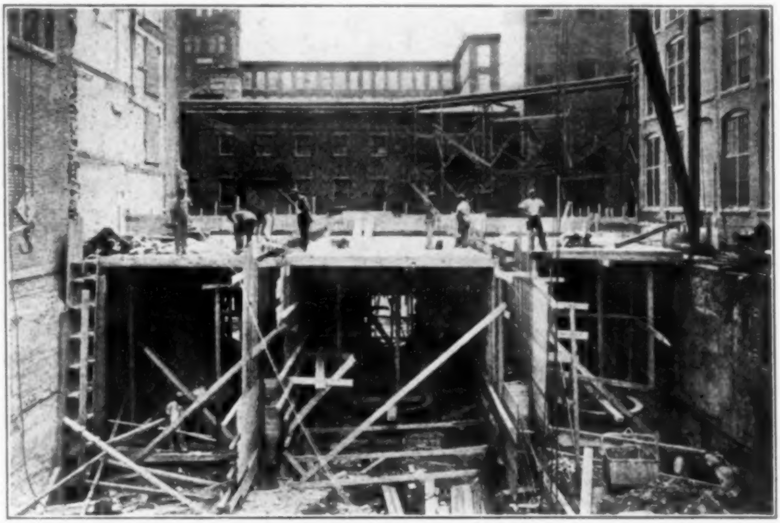

Fig. 14 Waterways, Draft Tubes and Turbine Room Floor, Bigelow Carpet Company

denser should they have to run for long periods when the dye house is not in operation. The reducing valve connection direct from high-pressure to low-pressure lines is also located in this room.

98 The operating switch mechanism for generating and distributing circuits from the steam turbines and three waterwheel generators is all controlled from the lower switchboard gallery, the switchboard carrying the indicating and recording instruments being mounted here. The oil switches are mounted in the gallery above. This portion of the apparatus was furnished by Westinghouse Company.

99 A set of gages from all important lines in the station is

also mounted on a special panel of this switchboard. The attendant thus has the whole working of the station at all times under control and he so adjusts the loads on the non-condensing and condensing machines as to maintain a constant pressure in the low-pressure manufacturing steam line.

100 *Turbine Casing Drainage.* Each of the three steam turbines being of the top exhaust type, is fitted with casing drains and traps to take care of whatever moisture may accumulate in the exhaust casing.

101 It will be interesting to note that the amount of con-

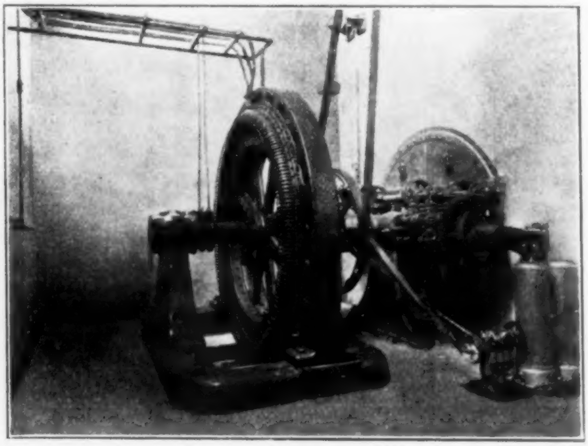

Fig. 15 Waterwheel Generator Pit, showing Generator and Water wheel Gate Mechanism, Bigelow Carpet Company

densation which experience has shown that these traps have to handle when machines are working against a back pressure, or in other words, delivering steam to a low-pressure system, is extremely small.

102 Gage glasses placed on the connection from turbine casing to trap and observed for long periods under running conditions show that there is almost no accumulation of condensation at this point. Whatever moisture may be present when leaving the last row of blades of these turbines practically all goes through with the steam into the low-pressure system.

103 *Moisture in Steam Leaving Turbine.* The writer was much interested to obtain as accurate information as possible

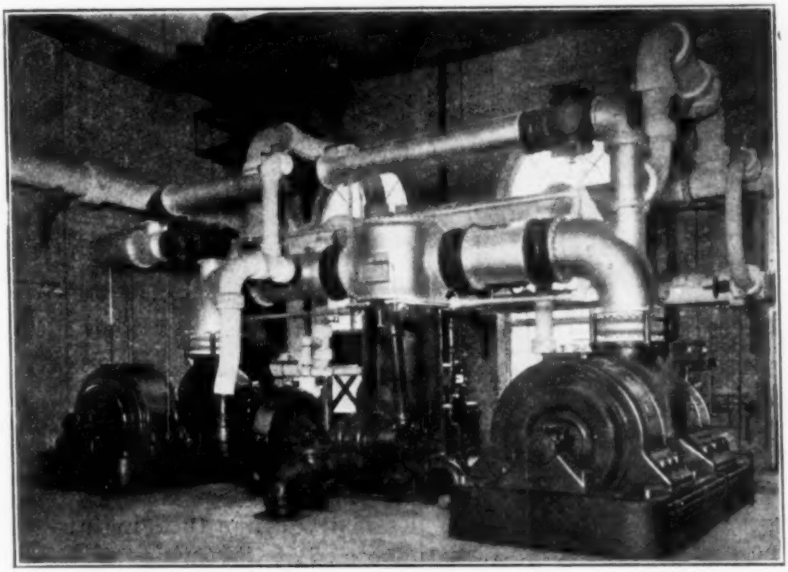

FIG. 16 END VIEW MAIN FLOOR OF TURBINE ROOM, SHOWING CONNECTIONS OF STEAM TURBINES FOR SUPPLYING STEAM USED IN MANUFACTURING, BIGELOW CARPET COMPANY

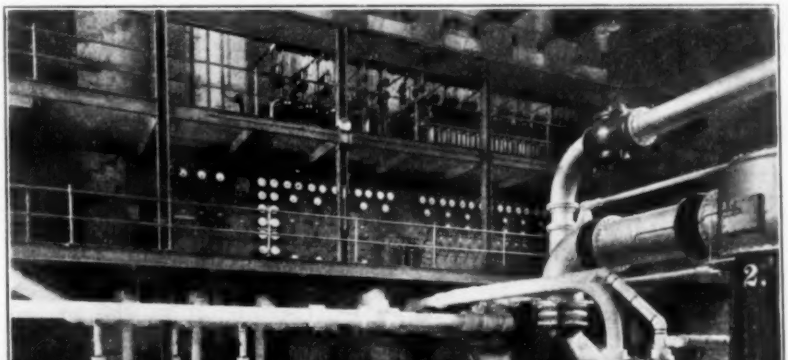

FIG. 17 SIDE VIEW TURBINES AND SWITCHBOARD, BIGELOW CARPET COMPANY

concerning the quantity of this moisture. In order to secure such results a set of tests with one of these turbines running under ordinary mill conditions, exhausting to the low-pressure system, and with loads varying over a wide range, was made January 19, 1912, by Prof. Charles W. Berry, of the Massachusetts Institute of Technology, using for this purpose a constant pressure superheating calorimeter. The steam at throttle of this turbine was slightly superheated, the amount being about 10 deg., as is the usual condition at this plant.

104 The quantities of moisture found were as follows:

With Load in Kw.	Moisture Per Cent
625	4.07
560	4.48
410	4.98
170	5.49

As would be expected, the per cent of moisture increases as the load decreases, the radiation losses of the turbine remaining practically a constant.

105 *Portion of Steam Chargeable to Power.* Adding to this, in the worst case, 5.5 per cent of moisture in steam leaving turbine for manufacturing use, the percentage representing the difference in heat energy between a pound of dry steam at 150 lb. boiler pressure and a pound of dry steam at manufacturing pressure of say, 6 to 7 lb. gage, we have about 9 or 10 per cent. Then increasing this by a liberal allowance for all losses and varying conditions, it seems to the writer that the quantity of steam which should be charged to power purposes when being exhausted from a steam turbine on its way to manufacturing or heating as above, does not exceed 12 per cent and that for the ordinary pressure ranges with practically dry saturated steam from boiler this value may well be used.

106 This station has been in full operation in the manner indicated and furnishing all power to the plant since June 1911. The entire substituting of motor for mechanical drives has in this case proved very satisfactory, as the grouping of buildings was such as to present many difficulties with any other system.

107 The quantity of work being done in the dye house sections is constantly increasing, and the portion of total power done on non-condensing turbines has proportionately increased.

ELECTRIC TRANSMISSION AND RELAY POWER

108 Lest it should be thought that the writer unduly favors electric transmission, inasmuch as most of the examples above mentioned have to do with the use of this method, it should be mentioned that this is not the case. The examples given were all taken from the work of his office during a short period which happens to cover a group of cases where flexibility was one of the most important determining factors. In these cases flexibility was most advantageously secured through electric transmission.

109 The greater portion of the plants, however, still contain older groups on direct mechanical drives. Where such drives are now in position, are reasonably direct and well constructed and where loads are fairly constant, their abandoning would certainly in many cases be undesirable.

110 Any new installation has to be considered with reference to its own special group of conditions and requirements taken together as a whole and in the writer's opinion no general rule can be laid down, for almost certainly there will be found cases where each form of transmission will be the cheapest and best.

RELAY POWER

111 By relay power is meant the power to supplement the usual or cheapest form of power and to take its place in case of failure. So far as the demands of textile mills are concerned, such power may be subdivided into two groups because of the different conditions affecting them.

112 Relaying almost always serves to relieve (*a*) either a shortage of water power which can be definitely foreseen and will take place in all plants in a given vicinity at the same time or (*b*) to furnish an added source of power available during times of accident to the ordinary equipment. It is then merely a form of insurance against events which can be expected to take place at no regular interval or predetermined time.

113 Mills using water power have usually had to provide for the first-mentioned kind and a group of such mills on a given stream must each provide for about the same proportion of such power.

114 *Auxiliary Equipment as Insurance Against Shutdowns.* When we come to the second form, however, it has in times

past been rather usual for textile plants to make little provision for added units to meet conditions of accident. This is due to the long period of shutdown during each 24 hours, allowing for ordinary repairs, and to the greatly increased cost for maintaining such equipment.

115 There is, however, a growing tendency to make some provision for added sources to relieve the danger of failure by the ordinary power. In many cases managers would be glad to increase this form of insurance greatly, could a proper solution of the question of cost be found.

116 In order to protect fully a group of independent plants would require duplicate equipment for their whole combined output, but this same group, if united together and provided with one source of relay power, could be, practically speaking, fully protected by an equipment very much less than that of the combined plants. The proportionate quantity of such equipment required to give protection would decrease rapidly with an increased number of plants served.

117 This supplying at low cost power connections, serving merely as an insurance against accident to the ordinary equipment, is a phase of power plant development which it seems to the writer should receive more attention than it has in the past.

118 *The Public Service Station as a Means of Supplying Insurance.* The public service corporation would seem to be in a position to undertake this service at rates which would be attractive and profitable both to itself and to those it would serve. With few exceptions, however, so far as the writer knows, little or nothing is being done by them at present time to develop this form of business. For the most part they at present insist upon a minimum charge which is practically the equivalent of all fixed charges on an equipment great enough to handle the full connected load of each unit served.

119 Such rates are of course in no way attractive to the manufacturer as under these conditions he can as well supply the added equipment in his own station and have it where he can control its use.

120 *Private Stations Serving Groups of Owners.* In certain sections of the country there is a growing recognition of the advantages of properly located groups of manufacturers combin-

ing to produce their power in a single station of large size rather than in individual stations.

121 There seems no reason why this idea should not prove of advantage in many cases with textile manufacturers. Such stations could be jointly maintained and run by them with very little increased overhead or supervision charges as there would be no expensive sales, inspection and advertising departments. The securing of relay power in this manner as an insurance against expensive shutdowns should be particularly attractive.

122 There are of course many difficulties in the way of carrying out such a scheme, principal among them that of having a group of individuals ready to act at a given time and the securing of rights of way for transmission lines. In connection with the latter strenuous opposition would sometimes have to be anticipated. The writer does not himself expect to see rapid developments along these lines, but nevertheless, believes that there will and should be a growing recognition of the wastefulness of some of our present seemingly necessary expenditures for duplicate power developments.

123 It seems reasonable that much more than in the past such portions of power required by textile mills as cannot be made a by-product of some other process will be produced in large central stations with the coal-burning units well removed from centers of population and so located as to give access to coal cheaply handled.

124 As electric energy can now be transmitted for long distances with comparatively small loss, there seems no reason why such stations for serving inland cities or groups of cities, like Lowell and Lawrence, should not be actually located at tidewater, and receive the full advantage of the reduced coal transportation rates which would thus result.

CASE CARBONIZING

By Marcus T. Lothrop

ABSTRACT OF PAPER

The case-carbonizing process requires an increasing of the carbon content of the surface of the material treated while the original composition of the interior is retained. It is essential that the details of the operation be understood to secure uniformity of product, and these researches were undertaken with the object of determining the causes of irregularity and the precaution which must be employed to secure uniform results.

The experiments undertaken were to determine:

a The effect of heat treatment in case-carbonizing steels upon the physical properties of the metal.

b The effect of temperature used in case carbonizing.

c The effect of heat treatment after case carbonizing.

d The effect on the rate and depth of carbonization of the composition of the steel being case carbonized.

e The efficiency of case-carbonizing materials

f The rapidity with which heat is conducted through carbonizing materials.

The conclusions deduced in each case are listed in the body of the paper under the headings corresponding to the several experiments, and the detailed results of the experiments are tabulated for further reference in the appendices.

CASE CARBONIZING

By Marcus T. Lothrop, Canton, Ohio

Junior Member of the Society

During the last decade the better understanding of the constitution of ferrous alloys and the improvement in apparatus have led to great advances in the commercial heat treatment of steel. The progressive manufacturer today carefully inspects the steels as received and before he allows them to enter his shop knows their composition and their physical condition. After the raw material is fabricated into finished parts, these parts are heat treated to show the desired physical properties. This operation of heat treatment must be conducted with certainty and uniformity and an inspection of existing conditions indicates that the uniformity is much greater when the manufacturer does not change the composition of the metal being heat treated. Case carbonizing, however, requires that the carbon content of the material on the surface be increased while the original composition of the material in the interior is retained. The operation requires that the user, in a sense, make his own steel and the details of the operation must be understood to the end that the operation may be conducted with the minimum cost and with the maximum certainty and that variations and irregularities shall not creep into the product.

2 The investigations indicate that, commercially, the case-carbonizing operation can be performed in such a manner that the final result will be absolutely uniform and that the advantages which accrue from case carbonizing represent the most efficient manner of obtaining the desired physical properties in many constructions. It was with the object of pointing out the causes of and the results effected by irregularity and the means

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

and precautions which must be employed to produce uniformity, that these researches were undertaken.

3 The following points were studied:

a The effect of the composition of the steel on the rate and depth of carbonization.

b The effect of heat treatment on case-carbonized steel.

c The effect of time on the rate and depth of carbonization.

d The effect of temperature and of composition of the steel on the depth and nature of carbonization.

e The efficiency of various commercial carbonizing materials.

f The effect of depth of case carbonizing on the physical properties of the finished materials.

g The commercial thermal conductivity of the various case-carbonizing materials.

h The efficiency of copper plating in preventing carbonization.

The materials used are summarized in Table 1.

EXPERIMENT NO. 1

THE EFFECT OF HEAT TREATMENT IN CASE-CARBONIZING STEELS (TABLES 12-21)

4 The determination of a test method which would indicate the physical properties of the metal tested required considerable trial. A case-carbonized piece of metal, consisting of a hard exterior and a soft and tough interior, is so dual in its physical characteristics that tensile tests are not adequate. This is due to the fact that when the case which is hard and brittle fails, the pull is suddenly applied to the reduced section of the core and causes it to fail so quickly that the expected ductility of the material fails to appear.

5 The test finally decided upon was a transverse test which has the advantage of approaching the condition of stress generally encountered in service. The test piece adopted was ½ in. round, 12 in. long, with 10 in. between supports, loaded at the center. A round section gives a case-carbonized zone of uniform depth in all parts and for this reason is superior to the flat section which has excessive depth in the corners. The 10-in. center to center distance between supports allows loads large

enough to be measured accurately and gives a deflection at rupture great enough to be easily measured. By means of this test, pieces of the same material and heat treated in identically the same way give results for strength and toughness which check closer than by any other method tried.

HEAT TREATMENT METHOD

6 These test pieces were packed in wrought-iron pots 23 in. long by 5 in. round, with 0.25 in. walls, so that each was 1 in.

TABLE 1 MATERIALS USED

No.		C	Si	Mn	P	S	Cr	Ni	V
2	0.15% C basic open hearth	0.15	0.02	0.68	0.054	0.043	....	....	....
3	0.20% C basic open hearth	0.20	0.02	0.66	0.038	0.044	....	....	....
4	0.25% C basic open hearth	0.25	0.04	0.61	0.038	0.046	....	....	....
5	0.10% C Halcomb electric furnace nickel steel	0.10	0.13	0.66	0.010	0.025	....	3.60	....
6	0.15% C Halcomb electric furnace nickel steel	0.15	0.09	0.70	0.009	0.013	....	3.54	....
7	0.20% C Halcomb electric furnace nickel steel	0.20	0.18	0.69	0.007	0.013	....	3.59	....
8	0.25% C Halcomb electric furnace nickel steel	0.25	0.21	0.74	0.009	0.009	....	3.55	....
9	0.31% C Halcomb electric furnace nickel steel	0.31	0.18	0.70	0.009	0.010	....	3.70	....
10	0.20% C Halcomb electric furnace chrome vanadium steel	0.20	0.13	0.50	0.009	0.010	1.00	....	0.15
11	0.50% C Halcomb electric furnace chrome vanadium steel	0.49	0.15	0.80	0.009	0.021	1.18	....	0.19
12	0.50% C Halcomb electric furnace chrome nickel steel	0.48	0.16	0.44	0.009	0.009	0.98	2.02	....

from the inside wall of the pot and 1 in. from each other. Case-carbonizing compound No. 1[1] was used in this experiment. The precaution of having everything clean and dry and the pots well and uniformly tamped down was carefully observed, and identical conditions of rate of heating, cooling and temperature maintained. The temperature was 1700 deg. fahr. with a variation of not greater than plus or minus 15. The test pieces after case carbonizing were cleaned and reheated in a neutral atmosphere to the temperatures given in Tables 12-21, Appendix No. 1, which are correct to plus or minus 10 deg. fahr. Table 2 sum-

[1] The analyses of these and other compounds are given in Table 7.

TABLE 2 INCREASES DUE TO HEAT TREATMENT

No.	Increase in Strength with Double Heat Treatment, Per Cent	Increase in Toughness with Double Heat Treatment, Per Cent	Drawing Single Treatment Increase		Drawing Double Treatment Increase		Annealing Single Treatment Increase		Annealing Double Treatment Decrease	
			Strength, Per Cent	Toughness, Per Cent	Strength, Per Cent	Toughness, Per Cent	Strength, Per Cent	Toughness, Per Cent	Strength, Per Cent	Toughness, Per Cent
2	23.0	105.0	12.0	25.0	....	....	10.0	26.0	....	....
3	25.0	56.0	21.0	4.0	....	....	16.0	4.0	....	....
4	12.0	80.0	12.9	18.2	....	....	14.3	18.4	....	....
5	20.0	10.8	24.8	10.8	9.1	20.0	2.4	6.5	....	....
6	6.1	....	23.0	17.8	11.0	10.0	4.1	....	....	....
7	5.6	13.6	27.4	20.5	14.5	16.0	4.0	....	1.5	6.0
8	6.9	19.0	29.6	43.0	17.0	23.8	1.5	2.4	0.7	8.0
9	6.9	....	34.4	27.6	25.0	40.5	4.1	2.1	3.3	....
10	10.7	92.5	14.3	25.0	16.7	13.6	2.8	7.0	....	....
Average carbon steel....	20.0	80.0	15.0	16.0	....	....	13.0	16.0	....	....
Average nickel steel........	8.0	14.0	27.6	24.0	15.3	20.0	3.6	2.0	1.1	3.0

marizes the results due to reheating and annealing, showing the increases in strength and toughness. Table 3 gives the temperatures at which the case ceases to be file hard as a result of drawing. All the tests recorded in the tables are the average of closely agreeing duplicates, and were made on test pieces which after heat treatment were file hard.

GENERAL CONCLUSIONS, EXPERIMENT NO. 1

7 A study of the tables leads to the following conclusions:

a Strength and toughness decrease with increasing depth of case. This is important commercially for with a certain steel and a certain heat treatment uniformity of strength and toughness is impossible if the depth of case varies.

TABLE 3 EFFECT OF DRAWING IN CASE-CARBONIZED STEELS

No.	Steel No. Grade	Temperature at which Case Ceases to be Glass hard, deg. fahr.
1	1—.10 per cent—C—Bessemer	425
2	2—.15 per cent—C—O. H.	425
3	3—.20 per cent—C—O. H.	425
4	4—.25 per cent—C—O. H.	425
5	5—.10 per cent—C—E. F. Ni.	425
6	6—.15 per cent—C—E. F. Ni.	425
7	7—.20 per cent—C—E. F. Ni.	425
8	8—.25 per cent—C—E. F. Ni.	425
9	9—.30 per cent—C—E. F. Ni.	425
10	10—.20 per cent—C—E. F. Cr. V.	450

The temperatures are such that the case can just be touched with a new fine file.

b The critical depth of case at which maximum brittleness and minimum strength occur, depends upon the initial carbon content of the steel which is case carbonized. The higher the original carbon content, the smaller the ratio of depth of case to diameter of core at the point where this brittleness occurs. The commercial importance of this point is that the manufacturer using the steel for case carbonizing should know its composition and should vary the depth of the carbonizing effect as demanded by the composition of the metal being used.

c Strength and toughness increase with double heat treat-

ment. This result is to be expected, for the dual nature of case-carbonized steel requires two thermal treatments properly to refine the composite metal.

d Strength and toughness increase when the temper is drawn at 380 deg. fahr. This operation does not decrease the hardness but relieves in a greater or less degree the strains set up in hardening and makes for uniformity as well as more pronounced physical properties.

e Annealing after case carbonizing is a doubtful operation. The physical improvement with single heat treatment may be obtained by resorting to double heat treatment, for the results will be better and the time consumed in the operation much shorter. Annealing does not improve the double heat treated pieces and may even cause loss of strength and toughness, due to the decarbonization which may take place. Annealing is not to be recommended.

f The case-carbonized steel will, with either double or single heat treatment, become file hard at temperatures too low for the best development of the maximum strength and toughness. Although seemingly paradoxical, the dual nature of the steel after case carbonizing will explain this established fact, when one recalls that the transformations of the exterior are first completed at low temperatures, and that those of the interior are last completed at higher temperatures.

g All steels lose their file hardness when drawn at 425 deg. fahr., save chrome vanadium which loses it at 450 deg. fahr.

h The ideal heat treatment for a case-carbonized steel may be assumed to be: Case carbonize to the thinnest possible depth of case demanded by the conditions of service; reheat for the core; quench in a suitable fluid; reheat for the case; quench in a suitable fluid; draw the temper as far as the conditions of service will permit.

i Case-carbonized steel parts, such as gears, etc., may be stronger, tougher and harder than similar parts made from oil-hardened steels.

EXPERIMENT NO. 2

MICROSCOPIC EXPERIMENT ON THE EFFECT OF HEAT TREATMENT AFTER CASE CARBONIZING

8 The object of this experiment was to determine, if possible, the constitutional difference between a case-carbonized bar of steel which had received a single heat treatment (reheating being a compromise, in that the temperature selected may be a little too high for the best refinement of the carbonized zone, and a little too low for the best refinement of the core), and a piece of the same metal carbonized in the same manner which had received a double heat treatment, the first reheating designed to be the best possible for the interior or the core and the second reheating designed to be the best possible for the case or carbonized zone.

9 Steels Nos. 3, 7 and 10 were case carbonized at 1300, 1400, 1500, 1600 and 1800 deg. fahr., and were treated with the best single and double heat treatments as detailed in Experiment No. 1. The specimens were etched for 10 seconds in a 1 per cent nitric acid solution. All specimens were martensitic with double heat treatment.

a The martensite was easily distinguished in steel No. 3 (0.20 per cent carbon open hearth) at 100 diameters magnification.

b The martensite was distinguished with difficulty in the No. 7 steel (0.20 per cent carbon electric furnace nickel steel) at 100 diameters magnification.

c The martensite was not distinguishable in steel No. 10 (0.20 per cent carbon chrome vanadium steel) at 100 diameters magnification. Martensite was barely distinguishable in this steel at 400 diameters magnification.

10 With single heat treatment

a The martensite was very easily distinguished in the No. 3 steel at 100 diameters magnification.

b The martensite was easily distinguished in the No. 7 steel at 100 diameters magnification.

c The martensite was just barely distinguishable in the No. 10 steel at 100 diameters magnification. At 400 diameters the martensite with this steel was easily distinguished.

11 The results of this experiment indicate that the double heat treatment increases the strength and toughness of case-carbonized steels due to the smaller and finer martensitic structure developed.

EXPERIMENT NO. 3

THE EFFECT OF TEMPERATURE USED IN CASE CARBONIZING

12 The object of this experiment was to determine the lowest temperature at which case carbonizing begins; the lowest temperature with each of the three different types of case-carbonizing steels (straight carbon and alloy, all of the same carbon content) at which it might be most efficiently conducted in practice; and the best temperature for the case carbonizing of steel.

13 The following steels were used:

a No. 3 0.20 per cent carbon open-hearth carbon steel
b No. 7 0.20 per cent carbon electric nickel steel
c No. 10 0.20 per cent carbon electric chrome vanadium steel

14 The test pieces were ½ in. round and 6 in. long, properly numbered for identification; three, one of each grade of steel, were packed in a pot for each run. The pot used in this experiment was made of 4 in. round wrought iron 8 in. long with ¼ in. wall. A solid steel plug was welded into one end, and the other end was fitted with a removable sheet-steel cover which was drilled in the middle with a hole large enough to accommodate the electro-thermo-couple protection tube. The test pieces were placed in the pot, equally spaced about the electro-quartz protection tube in the center and packed tightly in case-carbonizing compound No. 1. All heating was done in a gas-fired muffle furnace. Temperature readings of the furnace temperature and the inside temperature of the pots were taken every 15 minutes. Standardized platinum platinum-rhodium thermo-couples were used. Six runs of 5 hours each at a definite temperature were made, using the same apparatus and procedure. The six runs were at the following temperatures in deg. fahr.

No. 1	1300	No. 3	1500	No. 5	1700
No. 2	1400	No. 4	1600	No. 6	1800

15 The furnace was started cold in each case and time was counted from the time the pot couple showed a temperature in-

side the pot corresponding to the temperature for which the run was intended. After this, the pot temperature was maintained as close as possible to this point for an uninterrupted period of 5 hours, at the end of which time the pot couple was removed, the pots pulled from the furnace and allowed to become cold.

16 The temperature records of this series of experiments are given in Tables 22-27 of Appendix No. 2. Following these tables in the same appendix is a detailed analysis of the microscopic examinations of the various test pieces after being subjected to the heat treatment and specimen microphotographs are reproduced in Figs. 18 to 30, shown full size.

17 The conclusions to be drawn from this analysis follow herewith together with a tabulated statement (Table 4) of the thickness, in millimeters, of the zone of excess cementite, of the eutectic, of the gradation zone and the total penetration of carbon in millimeters for the different steels.

CONCLUSIONS FROM MICROSCOPIC INVESTIGATION OF OPEN-HEARTH STEELS CASE CARBONIZED AT 1300 TO 1800 DEG. FAHR.

18 In the specimen treated at 1300 deg. fahr. a small zone of carbonization was clearly separated from the interior material having a great number of penetrating bands containing the so-called nitrides in very minute needles. In the gradation zone these nitrides appeared in large quantities in larger needles.

19 In the specimen treated at 1400 deg. fahr the carbonized zone was slightly thicker and the gradation zone larger, giving a more gradual division between the carbonized and interior material. The penetrating bands were present as before in large numbers. Nitrides were still present inside the eutectic zone, but not in such great numbers as in the first specimen.

20 In the specimen treated at 1500 deg. fahr. the carbon penetration was slightly deeper, and a zone of excess cementite was found on the outside, which appeared as large irregular areas and as polygonal outlines. No nitride needles of any kind were visible.

21 The specimens treated at 1600 deg. fahr. and 1700 deg. fahr. showed still deeper penetration of carbon, greater excess of cementite, and a larger number of cementite needles.

22 At 1800 deg. fahr. there was a much greater penetration of carbon with an outer zone of excess cementite, but this cement-

ite did not occur in polygonal outlines, except in a few places. The general appearance of the carbonized zone was that of a eutectic, containing areas of excess cementite, grading to the normal carbon content of the interior.

CONCLUSIONS FROM MICROSCOPIC INVESTIGATIONS OF NICKEL STEELS CASE CARBONIZED AT 1300 TO 1800 DEG. FAHR.

23 In this series there was a slight carbonization in the speci-

TABLE 4 SUMMARY CASE-CARBONIZING EXPERIMENT NO. 3

Temperature, Deg. Fahr.	Excess Cementite O. H.	Excess Cementite Ni	Excess Cementite Cr Va	Thickness of Eutectic O. H.	Thickness of Eutectic Ni	Thickness of Eutectic Cr Va
1100	.....	.....	.....	.....	.....	.....
1200	.....	.....	.....	.....	.....	.....
1300	0.008	.....	trace	0.090	.....	.....
1400	0.090	.....	0.009	0.120	0.203	0.030
1500	0.128	0.056	0.285	0.150	0.278	0.135
1600	0.135	0.158	0.375	0.210	0.390	0.180
1700	0.225	0.293	0.465	0.338	0.488	0.248
1800	0.293	0.390	0.338	0.450	0.390	0.405

Temperature, Deg. Fahr.	Gradation Zone O. H.	Gradation Zone Ni	Gradation Zone Cr Va	Total Penetration of Carbon O. H.	Total Penetration of Carbon Ni	Total Penetration of Carbon Cr Va
1100	.....	.....	.....	.....	.....	.....
1200	.....	.....	.....	.....	.....	.....
1300	0.034	0.180	0.016	0.140	0.030	0.180
1400	0.188	0.390	0.300	0.410	0.590	0.420
1500	0.420	0.510	0.338	0.710	0.830	0.770
1600	0.450	0.683	0.278	0.770	0.990	0.890
1700	0.600	0.975	0.450	1.160	1.560	1.370
1800	0.683	0.900	0.675	1.640	2.030	1.750

The measurements in this table give the width of zones in millimeters.

men treated at 1300 deg. fahr. only, and no penetration bands similar to those of the open-hearth series which contained nitrides.

24 In the specimen treated at 1400 deg. fahr. there was a better penetration of carbon, but no higher carbon content on the outside than eutectic. Several of the penetrating bands were present.

25 At 1500 deg. fahr. there was a still greater penetration of carbon, but little if any excess cementite on the outside, and few of the penetration bands were present in this specimen.

26 In the 1600 deg. fahr. specimen there was a normally increasing depth of case, with a slight amount of excess cementite on the outside and bands of penetrating material.

27 In the specimen treated at 1700 deg. fahr. there was still greater penetration of carbon and an increase in the excess cementite on the outside of the carbonized zone. In this specimen there were also a few penetrating bands. The cementite existed as crystal boundaries and as needles in the crystal cleavages.

28 In the specimen treated at 1800 deg. fahr. a great deal of excess cementite was found on the outside, as well as greater penetration of carbon and no penetrating bands. This series differed from the open-hearth series in that the excess cementite and the excess ferrite in their respective zones did not tend so uniformly to form the polygonal outlines as they did in the open-hearth series. Also either no nitrides were present in this series, or, if they were in the penetrating bands, they were in a different form from any nitrides so far observed.

CONCLUSIONS FROM MICROSCOPIC INVESTIGATION OF CHROME VANADIUM STEELS CASE CARBONIZED AT 1300 TO 1800 DEG. FAHR.

29 In this series, the specimen treated at 1300 deg. fahr. showed a small zone of carbon, the highest carbon content on the outside being about eutectic.

30 In the specimen treated at 1400 deg. fahr. there was a very slight rim of cementite and pearlite in about equal amounts, while at 1500 deg. fahr. the excess cementite was found in two distinct zones, the outer zone containing the cementite in large globules intermingled with pearlite, the inner zone of polygonal outlines of cementite surrounding pearlite areas.

31 At 1600 deg. fahr. the cementite appeared in two zones as at 1500 deg. fahr.

32 At 1700 deg. fahr. the double zone appearance of the cementite was not so marked, and at 1800 deg. fahr. only one zone contained the cementite in polygonal outlines. The polygons as a rule appeared to be larger towards the inner part of the zone.

GENERAL SUMMARY OF THE EFFECT OF TEMPERATURE IN CASE CARBONIZING

33 The following is a general summary of the effect of temperature in case carbonizing:

a The depth of case carbonizing effect in a given time increases with the temperature.

b The carbon content in the case-carbonized zone in a given time increases with the temperature. This affords the commercial opportunity of varying the depth of case-carbonizing effect as desired by changing the time, and of varying the carbon content of the case-carbonized zone by changing the case-carbonizing temperature. It is poor practice to raise the temperature of the case-carbonizing operation for the purpose of reducing the time which the operation consumes, for this will increase the maximum carbon content of the case-carbonized zone and may change the character of the physical properties of the finished product.

c The minimum temperature at which uniform penetration of carbon can be obtained with case carbonizing seems to be 1500 deg. fahr. With lower temperatures the carbon maximum is not uniform in its distribution and the penetration too slow.

d The presence of excess cementite in the form of needles within the pearlite grains, so conspicuous in nickel and carbon steels, indicates a temperature during case carbonizing which overheats the metal being so treated.

e Nickel steel gives the greatest total penetration and greatest gradation zones.

f Chrome vanadium gives the highest carbon maximum and finest grained steel.

g When case carbonizing is conducted at 1400 deg. fahr. or lower, the carbon maximum does not exceed the eutectic. As the case-carbonizing temperature increases, a zone of hypereutectic composition develops which increases in depth with the temperature. The depth of this zone becomes important when sufficient warpage takes place in the piece being hard-

ened to demand grinding after the final heat treatment. It has been demonstrated often that a carbon content of more than 1 per cent in the surface of a case-carbonized part is undesirable when there is the least shock to be reckoned with, because in such instances the excess of carbon exists in the form of films of carbide between the grains of the metal which are brittle and hard, weakening the steel and rendering it liable to fail by flaking off or spawling. Therefore it would be inadvisable to select a practice or a material which produces such a condition in the surface. On the other hand if the carbon percentage is lower than 0.90 to 1.00 per cent the case will not show its maximum hardness. Therefore, when pieces are to remain unground practice should aim at a production of a 0.90 per cent carbon surface but when a portion of the steel is to be ground off, after the heat treatment, it is advisable to drive in an excess of carbon so as to leave this optimum percentage of 0.9 to 1.00 per cent in the final surface.

h All carbonized zones widen with increase of temperature. While wide gradation zones are desirable from the point of view of tenacity of the case to the core, other considerations enter into the commercial side of the problem. The first is the cost of maintaining the high heats. The factors of fuel cost and increased furnace up-keep cost at the upper temperatures are self-evident. The second is the difference in the nature of the case. Inspection will show that at 1500 deg. fahr. the width of the eutectic zone is considerably greater than that of the hypereutectic zone and the hypoeutectic zone of the decreasing carbon content is wider still, which means, of course, that the case carbonizing is proceeding gradually and that the case and core are merging into each other by gentle degrees. At 1600 deg. fahr. the ratio of the high carbon exterior zone to the inner zones rises and at 1700 and 1800 deg. fahr. the increase is more marked still.

The meaning of all this is that as the temperature goes up carbon is forced by the heat, as it were, to rush

into the surface of the steel faster than it can be assimilated by the adjacent grains and so the outside layers at the high heats are gorged with carbon which has not time to diffuse gradually toward the center of the case. This condition of affairs is highly undesirable, because the product then shows a sharp demarcation between case and core, the transition from one material to another being too abrupt; the properties necessarily vary accordingly and in the finished piece have a tendency to set up high physical strains. This causes flaking off of the case from the core, a phenomenon familiar enough to those engaged in the trade. The remedy is to case carbonize at a moderate heat for a length of time sufficient to obtain a reasonable depth of case with gradual transition from case to core. This temperature appears in this experiment to be about 1650 deg. fahr. with open-hearth carbon steel, 1600 deg. fahr. with electric nickel steel, and 1650 deg. fahr. with electric chrome vanadium steel.

In deciding upon the best carbonizing temperature, the effect of heat on the size of grain in the steel must also be considered. This as is well-known, is a very decided reaction, the grain coarsening rapidly with increasing temperatures. In this connection a careful investigation showed marked contrast between the behavior of ordinary carbon steel and the two alloy steels; the former began to coarsen rapidly at 1500 deg. fahr.; nickel steel also showed the same effect at the same temperature but in a much less marked degree and chrome vanadium steel retained its fine grain up to 1700 deg. fahr. and over, not reaching even at 1800 deg. fahr., the grain size of other steels. This is in line with the common belief that chromium and vanadium retain fineness of grain in steel.

EXPERIMENT NO. 4

THE EFFECT OF THE COMPOSITION OF THE STEEL BEING CASE CARBONIZED ON THE RATE AND DEPTH OF CARBONIZATION

34 The object of this experiment was to determine by chemical analysis the depth of carbonizing effect and carbon content of several zones of case carbonizing effect as affected by the composition of the steel being case carbonized.

35 Test bars 8 in. long and 1½ in. round were prepared by machining on centers in a lathe and packed in case-carbonizing compound No. 1, care being taken to see that all bars were evenly spaced. The bars were case carbonized at 1700 deg. fahr. for 7 hours. The pot was then removed from the furnace and

TABLE 5 EFFECT OF COMPOSITION OF STEEL IN CASE COMPOSITION AFTER CARBONIZING

No.	Material	Percentage of Carbon in Cuts of Various Depths, In.					
		0 to 0.005	0.005 to 0.010	0.010 to 0.015	0.015 to 0.020	0.020 to 0.025	0.025 to 0.030
1	No. 1 0.10% C Bessemer	0.90	0.63	0.32	0.16	0.13	0.11
2	No. 3 0.20% C O. H.	0.95	0.78	0.47	0.27	0.20	0.20
3	No. 6 0.15% C E. F. Ni	0.90	0.65	0.44	0.28	0.19	0.15
4	No. 9 0.30% C E. F. Ni	0.95	0.75	0.55	0.34	0.30	0.30
5	No. 10 0.20% C Cr Va	1.22	0.78	0.49	0.30	0.20	0.20

allowed to become cold, when it was unpacked and the bars removed and cleaned. The bars were set up in a lathe and cuts 0.005 in. deep taken. The sample thus obtained was analyzed by combustion and in duplicate for carbon, and the results will be found in Table 5. The information obtained from this experiment indicates that:

a The higher the carbon content of the steel case carbonized, the higher will be the maximum carbon content of case when case carbonizing is performed at a given temperature for a given time.

b The original carbon content does not affect the depth of case under the conditions of this experiment.

c The nickel and carbon steels behave similarly in regard to carbon maximum.

d Chrome vanadium steel takes a higher carbon maximum than nickel steel and carbon steel under the same case-carbonizing conditions.

EXPERIMENT NO. 5

EFFICIENCY OF CASE-CARBONIZING MATERIALS

36 This experiment was undertaken to determine the commercial efficiency of case-carbonizing materials and to show the elements which affect their value commercially.

37 Fourteen case-carbonizing materials were selected, representing the most prominent compounds used in this country. Fifty-pound samples were obtained on the open market from the several manufacturers, with prices, general description, etc. As soon as received average samples of about 1 pint each were taken, put in stoppered bottles, and sent to the chemical laboratory for analysis and specific gravity determination. These compounds are designated as Nos. 1, 2, 3, etc., in Table 4. The bars used in making up the test pieces (Table 1) were selected by chemical analysis and were all of 0.20 per cent carbon.

38 The test pieces were of three different types:

a Solid cylinders 6 in. long by 1.344 in. in diameter. These were cut to length and turned from 1⅜ in. diameter hot rolled and annealed bars; set up on centers in lathe and rough turned true and straight and close to finish size; finished absolutely straight and to size by grinding on centers. This left the bars entirely bright and with an almost polished surface ready for carbonizing.

b Hollow cylinders 6 in. by 1¼ in. outside diameter by ¼ in. thick wall. These were also made from 1⅜ in. diameter, hot rolled and annealed bars, turned to size and bored; not ground.

c Solid rod ½ in. in diameter by 6 in. long. Samples were cut to size from ½ in. in diameter (cold drawn) bars and sand-blasted, and all test pieces properly numbered for identification. Carbonizing pots used were new and of cast iron, rectangular in shape, inside dimensions 10 in. by 6¼ in. deep, with ½ in. thick wall. They were supported on legs ¾ in. off

furnace floor and prevented from touching each other in furnace by a boss 1½ in. long on each end (Fig. 1).

39 Packing the pots was done as carefully and as nearly uniform in each case as possible. Three test pieces, one of each type, were used in each pot and were spaced as indicated.

40 A layer of carbonizer about 1½ in. thick was put in first and tamped down, then the lowest bar with more carbonizer, etc., tamping in snugly throughout, and so on until the pot

TABLE 6 PHYSICAL AND PRICE DATA ON CARBONIZING MATERIALS

Carbonizing Material No.	Weight of 1 Pt., Grains	Approximate Specific Gravity	Weight of 1 Cu. Ft., Lb.	Volume of 1 Ton, Cu. Ft.	Cost per Cu. Ft.
1	450	0.954	59.4	33.7	$1.84
2	365	0.774	48.1	41.5	1.30
3	438	0.930	57.5	34.5	1.50
4	418	0.870	55.5	36.3	1.48
5	436	0.925	57.5	34.8	1.58
6	285	0.604	37.6	53.2	0.85
7	259	0.550	34.2	58.5	1.02
8	373	0.720	49.2	40.6	0.86
9	248	0.526	32.7	61.1	1.64
10	126	0.267	16.6	120.4	....
11	363	0.770	47.8	41.8	1.31
12	448	0.950	59.1	33.8	....
13	287	0.608	37.8	52.9	1.32
14	298	0.630	39.3	50.9	1.77

was full. The cast-iron covers were luted on with clay, small "tell-tales" inserted in one end, and pots put into the furnace.

41 The original weight of test pieces and carbonizing material used in each pot were obtained before each run.

42 The American Gas Furnace Company's gas-fired muffle furnace No. 4 was used in case carbonizing. It was found possible to run six pots at a heat, equally spaced in muffle, not touching each other or the sides of furnace. Furnace-working temperatures were obtained by regular Le Chatelier type thermocouple, the hot end of which projected down between the pots in the middle of the muffle. Each of the six pots used in a run contained a different kind of carbonizing agent. Three consecutive runs were made on each kind, the material from the preceding run being used in each case except, of course, the

first run, which was on new raw material. New test pieces were used for each run of each kind of carbonizer.

43 In conducting the carbonizing runs, the furnace working conditions were maintained as nearly uniform in each as possible. Pots were arranged in the muffle in the afternoon ready for starting and at 7 a.m. the furnace was lighted. The temperature was worked up at a fairly rapid rate and very close to 9 a.m. it had reached 1750 deg. fahr. in all cases. This temperature was maintained uniformly throughout the day and up to 6 p.m. when the furnace was shut off and furnace and pots were allowed to cool slowly over night. Subsequent examination included:

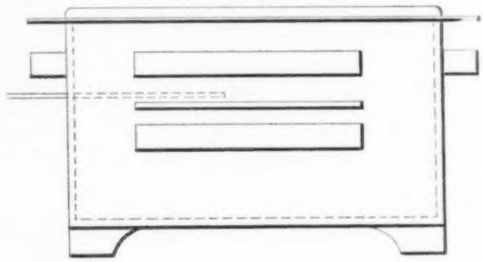

Fig. 1 Diagram showing Location of Test Pieces in Carbonizing Pot

a Thorough examination of general appearance of pots, carbonizing material and test pieces after unpacking: weights obtained to show loss of weight of carbonizer, or gain of weight of test pieces, loss of volume of carbonizer. The mixtures were carefully saved and used without further rejuvenation, in packing the pots for the next run. Shrinkage in volume was taken care of by using sufficient sand to fill up pots. This was done by placing the added sand in the bottom of the pot.

b Taking of cuts from solid cylinders for analysis. Bars after carbonizing, were carefully cleaned of all dirt, etc., set up on centers and tested for straightness or straightened, if necessary, until they ran absolutely true on centers. Then 11 consecutive cuts of 0.005 in. each on radius were taken, the length of the bar and turnings carefully kept separate and put in en-

TABLE 7 ANALYSIS OF CARBONIZING MATERIALS

Number of Material	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Price per Ton, Dollars and Cents	62	55	52	53.60	....	45	60	35	100	...	55	...	70	90
Approximate Analysis, Per Cent														
Moisture	5.65	5.57	6.50	5.90	7.03	2.4	1.70	2.26	4.60	4.10	1.55	0.45	6.15	0.85
Volatile Matter	31.17	33.73	32.90	33.14	30.87	25.77	10.73	12.43	10.90	15.95	32.35	23.10	54.95	15.53
Fixed Carbon	0.15	1.00	0.05	1.20	0.60	37.75	60.32	58.30	78.62	75.80	15.60	57.93	22.20	30.82
Ash	63.03	59.70	60.55	59.76	61.50	34.02	27.25	26.04	5.88	4.15	50.50	18.52	16.70	52.80
	100.00	100.00	100.00	100.00	100.00	99.94	100.00	99.03	100.00	100.00	100.00	100.00	100.00	100.00
Ash Analysis, Per Cent														
Calcium Oxide	34.31	32.27	not determined	not determined	33.49	17.00	7.95	6.64	0.52	0.67	26.17	8.39	6.68	....
Phosphorus Pentoxide	29.00	27.28			28.30	14.02					23.40	3.30	5.93	
Aluminum Oxide	.....	.....			.....	1.82	3.97	2.62	0.35	0.49	0.76	0.52	0.28	0.58
Iron Oxide	.....	.....			.....									
Silica	.....	.....			.....	0.58	5.76	5.46	0.11	0.08	0.34	0.79	0.69	1.58
Carbon Dioxide	.....	.....			.....	....	....	....	0.46	....	....	....	....	10.68
Sulphur Trioxide	.....	.....			.....	0.65	2.12	2.15	1.85	1.62	0.80	1.60	0.90	1.52
Sodium Oxide	.....	.....			.....	....	6.45 (by difference)	10.13 (by difference)	....	....	....	....	....	....
Magnesium Oxide	.....	.....			.....	....	....	....	1.43	1.18	....	3.29	0.63	0.68
Barium Oxide	.....	.....			.....	....	....	....	1.62	....	....	....	....	37.24
	100.28	99.85			100.29	100.05	99.00	100.00	100.46	99.89	100.97	99.37	98.41	99.48
Solid Matter and Carbon Dioxide, in the Carbonizer														
Total Combustible Carbon	12.51	14.07	15.86	14.88	13.50	53.42	66.24	65.88	78.41	77.66	41.42	70.11	40.02	44.93
Carbon Dioxide as Carbonates	3.51	2.95	not determined	not determined	3.43	0.62	4.62	4.35	1.20	0.75	1.18	7.36	0.89	11.63
Total Sulphur	0.16	0.10		....	not determined	0.26	1.03	0.97	0.74	0.65	0.24	0.64	0.36	0.61
Total Phosphorus	12.66	11.91		....		7.00	0.005	0.002	0.024	0.24	10.22	1.44	2.59	0.01
Sulphur as Sulphide	.....	.....	.....	....	.....	....	0.08	0.15	....	....	....	....	....	....
Hydro-Carbon Oils (soluble in gasoline)	.....	.....	.....	....	.....	....	....	....	....	....	23.82	....	....	....
Approximate Specific Gravity	0.954	0.774	0.930	0.88	0.92	0.60	0.79	0.55	0.52	0.27	0.77	0.95	0.61	0.63

TABLE 8 MEASUREMENTS IN MILLIMETERS OF ZONES AND CARBON PENETRATION OF TEST PIECES

SEE APPENDIX No. 2

Case-Carbonizing Material No.	Zone of Excess Cementite	Eutectic Zone	Gradation Zone	Total Penetration of Carbon
RUN No. 1				
1	0.455	0.455	0.650	1.560
2	0.450	0.650	0.748	1.848
3	.....	0.520	1.235	1.755
4	.....	0.975	1.300	2.275
5	0.780	0.520	0.975	2.275
6	.....	.....	1.235	1.235
7	0.325	0.520	0.975	1.920
8	0.455	0.520	0.975	1.950
9	1.235	0.423	0.780	2.438
10	.....	0.975	1.105	2.080
11	.....	0.195	1.300	1.495
12	.....	0.339	1.235	1.574
13	0.325	0.520	1.300	2.145
14	1.040	0.339	0.650	2.029
RUN No. 2				
1	.....	0.715	1.001	1.716
2	.....	0.650	1.073	1.723
3	.....	0.520	1.300	1.820
4	.....	0.878	0.975	1.853
5	.....	0.780	0.975	1.755
6	.....	.....	0.975	0.975
7	.....	2.260	1.300	1.560
8	0.325	0.715	0.910	1.950
9	1.075	0.455	0.780	2.300
10	.....	0.065	1.170	1.235
11	.....	.....	1.658	1.658
12	.....	0.130	1.560	1.690
13	.....	0.520	1.170	1.690
14	.....	1.300	0.450	1.105
RUN No. 3				
1	.....	0.358	1.138	1.496
2	.....	.....	0.975	0.975
3	.....	.....	0.325	0.325
4	.....	0.455	0.975	1.430
5	.....	0.225	1.300	1.525
6	.....	.....	0.040	0.040
7	.....	0.715	1.170	1.995
8	0.195	0.650	0.650	1.495
9	0.325	0.845	0.975	2.145
10	.....	.....	0.910*	0.975*
11	.....	.....	1.235†	1.242†
12	.....	0.007	1.560	1.567
13	.....	0.293	1.170	1.463
14	1.170	0.845	1.300	3.315

* On the outside of this specimen there was a rim of almost pure ferrite 0.065 mm. thick.
† On the outside of this specimen there was a rim of almost pure ferrite 0.007 mm. thick.

velopes for subsequent determinations of carbon, phosphorus and sulphur.

c Breaking of carbonized tube for general appearance and action of carbonizer in tubes, etc.

d Breaking of ½ in. round rod (some after heat treatment) for general appearance, depth of case, and microscopic examination.

44 In Table 6 are listed data concerning the 14 carbonizing materials and in Table 7 are given the analyses. In Figs. 2 to 15 are shown graphically the carbon contents of the carbonized sections of the test bars at successive depths, as explained in Par. 43 *b*. The captions of these diagrams give also the phosphorous and sulphur contents in each case at depths of 0.005 in. and 0.06 in. below the surface of the test bars.

45 In Appendix No. 3 is a detailed description of the results of the microscopic examination of the several bars and in Table 8 is summarized the measurements in millimeters, determined by the microscopic examination, of the zone of excess cementite, the eutectic zone, the gradation zone and the depth of carbon penetration.

46 In Table 9 are summarized physical and price data on the carbonizing materials in relation to the carbon penetration of the test bars.

47 The results of the experiment on the efficiency of case-carbonizing materials may be summarized as follows:

a The volume per ton of case-carbonizing materials varies. As these materials are used by volume, not by weight, this volume per ton must be considered in the economic purchase of this grade of material.

b All the compounds show shrinkage of volume and in most instances a loss of potency with continued service. This point is of greatest commercial interest since, if steel of variable carbon content is produced in the case-hardening process the manufacturer cannot hope for uniform results.

c With the compounds on the market, any desired maximum carbon content in the case can be obtained with a given temperature simply by varying the compounds used.

d When parts are produced which require grinding after

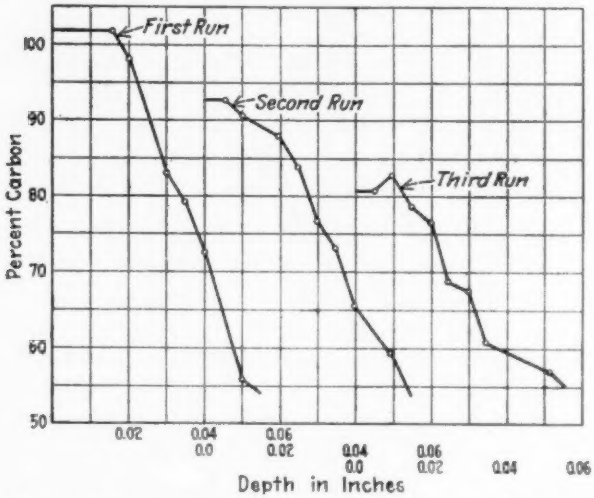

Fig. 2 Carbon Penetration Curves for Test Bars treated with Carbonizing Material No. 1
Phosphorus Content 0.025%–0.029%; Sulphur Content 0.04%–0.04%

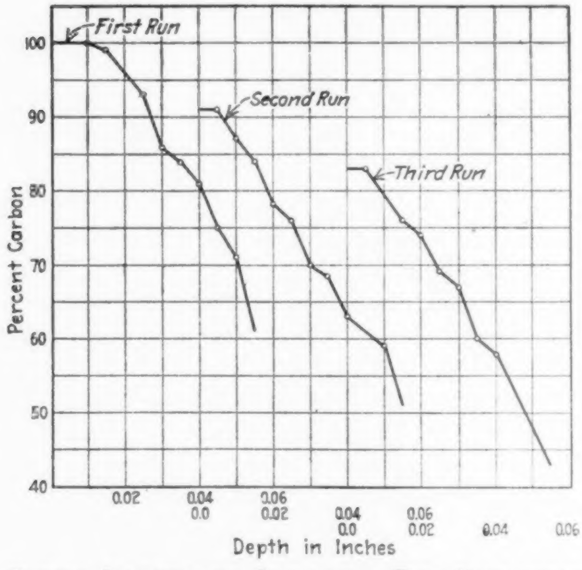

Fig. 3 Carbon Penetration Curves for Test Bars treated with Carbonizing Material No. 2
Phosphorus Content 0.030%–0.032%

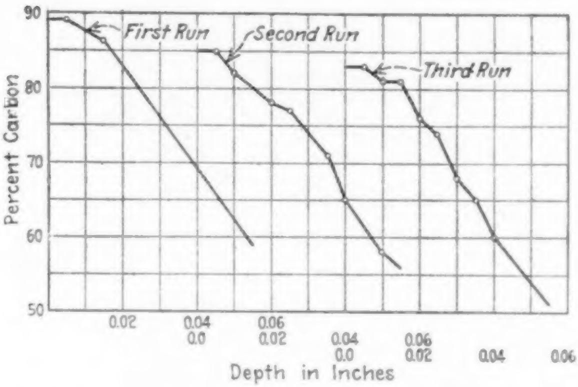

FIG. 4 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL NO. 3
PHOSPHORUS CONTENT 0.029%–0.033%

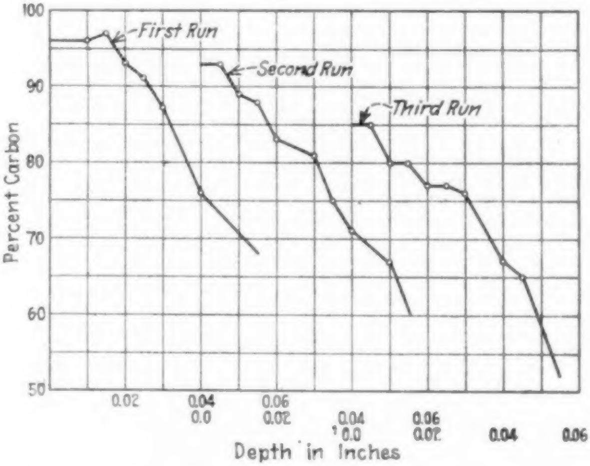

FIG. 5 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL NO. 4
PHOSPHORUS CONTENT 0.029%–0.036%

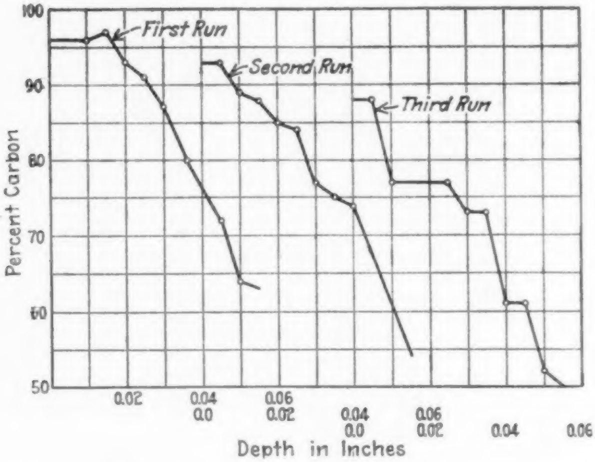

FIG. 6 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL NO. 5
PHOSPHORUS CONTENT 0.032%–0.038%

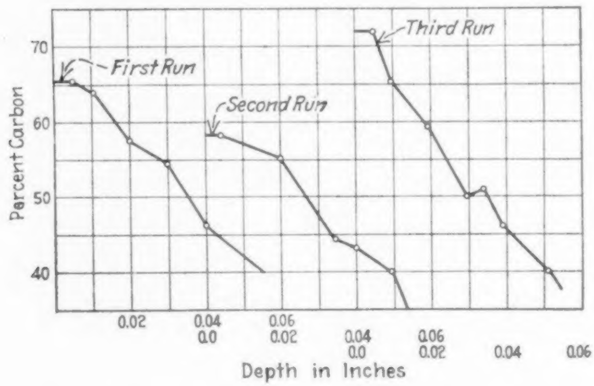

FIG. 7 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL NO. 6
PHOSPHORUS CONTENT 0.028%–0.030%; SULPHUR CONTENT 0.034%–0.040%

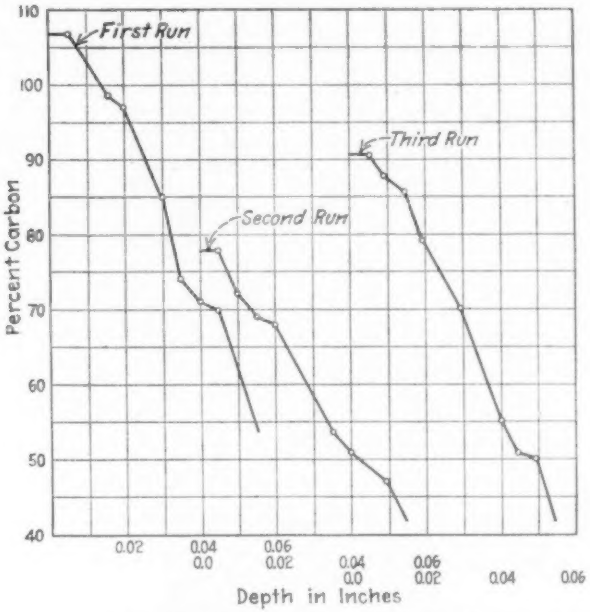

FIG. 8 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 7
PHOSPHORUS CONTENT 0.024%–0.033%; SULPHUR CONTENT 0.040%–0.044%

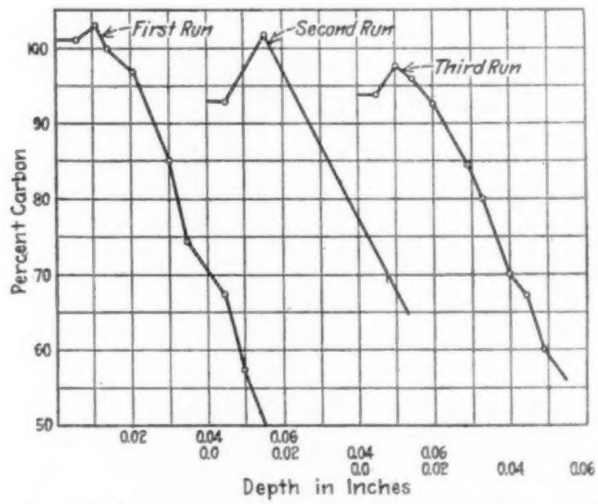

FIG. 9 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 8
PHOSPHORUS CONTENT 0.028%–0.031%; SULPHUR CONTENT 0.042%–0.046%

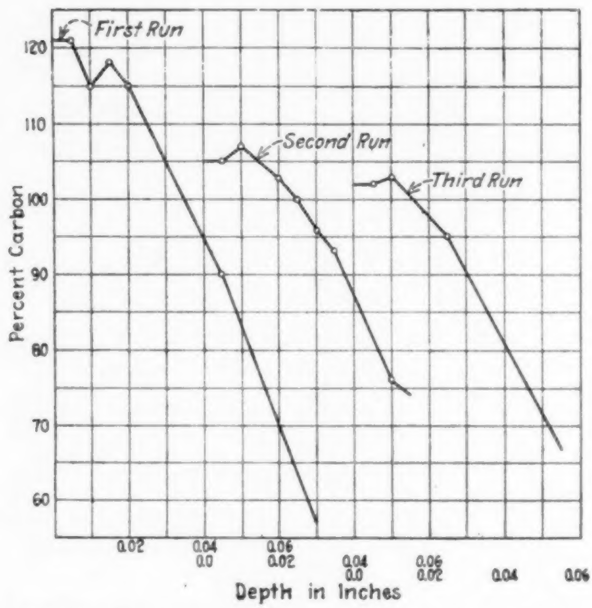

FIG. 10 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 9
PHOSPHORUS CONTENT 0.026%–0.036%; SULPHUR CONTENT 0.050%–0.054%

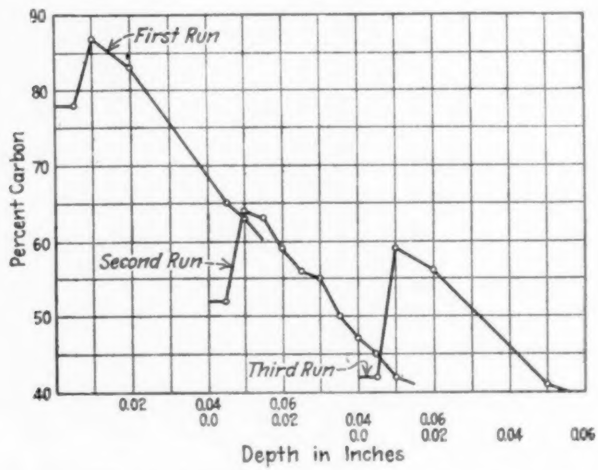

FIG. 11 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 10
PHOSPHORUS CONTENT 0.042%–0.035%; SULPHUR CONTENT 0.044%–0.042%

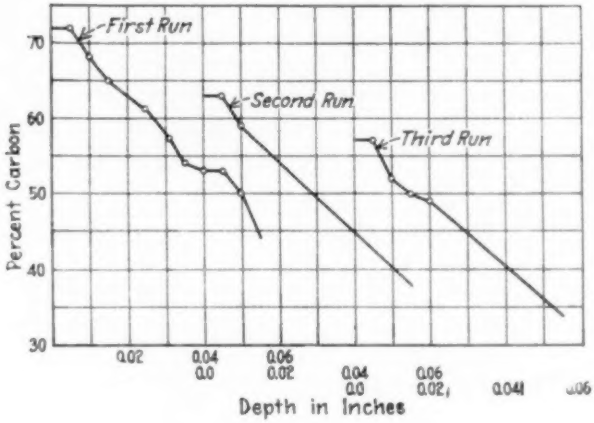

FIG. 12 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 11
PHOSPHORUS CONTENT 0.033%–0.036%; SULPHUR CONTENT 0.042%–0.042%

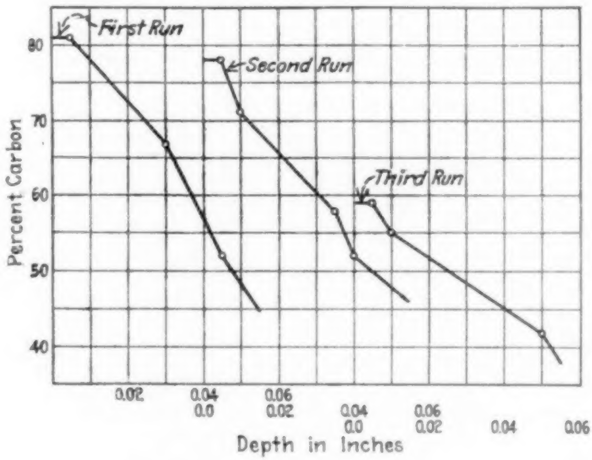

FIG. 13 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 12
PHOSPHORUS CONTENT 0.031%–0.036%; SULPHUR CONTENT 0.044%–0.044%

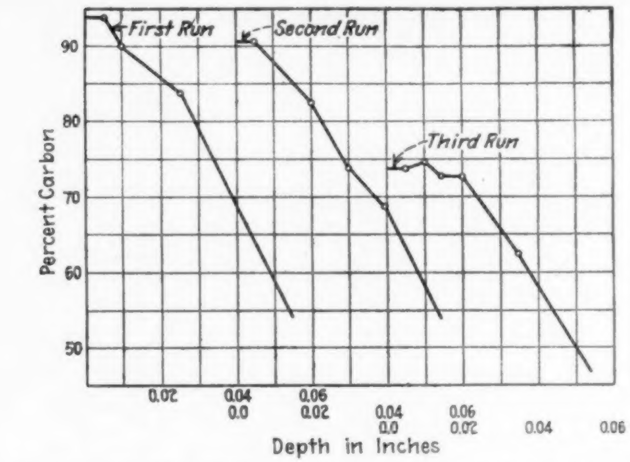

FIG. 14 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 13
PHOSPHORUS CONTENT 0.072%–0.032%; SULPHUR CONTENT 0.044%–0.042%

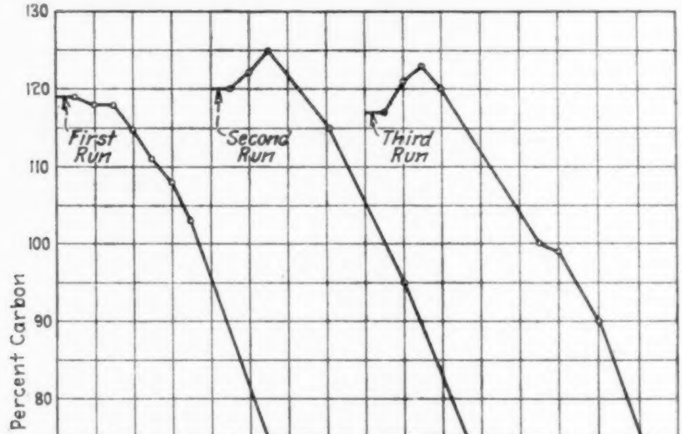

FIG. 15 CARBON PENETRATION CURVES FOR TEST BARS TREATED WITH CARBONIZING MATERIAL No. 14
PHOSPHORUS CONTENT 0.036%–0.034%; SULPHUR CONTENT 0.036%–0.042%

TABLE 9 PHYSICAL AND PRICE DATA ON CARBONIZING MATERIALS IN RELATION TO CARBON PENETRATION

Carbonizing Material No.	Carbon in Test Bars, Per Cent						Relative C Yielded in Satisfactory Tests per Unit Volume	Price per Cu. Ft.	Cost per Cu. Ft. per Unit
	Depth of 0.005 In.		Depth of 0.025 In.						
	1st	2d	3d	1st	2d	3d			
1	1.02	0.93	0.81	0.87	0.80	....	1.67	$1.84	$1.10
2	1.00	0.91	0.83	0.91	0.76	....	1.67	1.30	0.78
3	0.89	0.85	0.83	....	....	....	....	1.50	....
4	0.96	0.93	0.85	0.88	0.81	....	1.69	1.48	0.87
5	0.96	0.93	0.88	0.85	0.80	....	1.65	1.58	0.96
6	0.65	0.38	0.72	....	....	....	....	0.85	....
7	1.07	0.78	0.91	0.88	0.80	0.73	2.41	1.02	0.42
8	1.01	0.93	0.94	0.85	0.88	0.93	2.56	0.86	0.34
9	1.21	1.05	1.05	0.95	0.90	0.90	2.90	1.64	0.56
10	0.78	0.52	0.43	....	....	....	....	....	....
11	0.72	0.63	0.57	....	....	....	....	1.31	0.85
12	0.81	0.78	0.59	....	....	....	....	....	....
13	0.94	0.91	0.74	0.78	0.78	....	1.56	1.32	5.33
14	1.19	1.20	1.17	1.06	1.13	1.13	3.32	1.77	....

TABLE 10 THERMAL CONDUCTIVITY OF CARBONIZING COMPOUNDS

No.		Price per Ton	Weight per Cu. Ft.	Time to Heat to 1200° F., Min.	Per Cent of Fastest	Per Cent of Slowest
1	New case-carbonizing compound No. 8	$60	28	52	153	34.7
2	Old case-carbonizing compound No. 8	$60	28	34	100	22.7
3	New case-carbonizing compound No. 1	$57	52	145	425	96.5
4	Old case-carbonizing compound No. 1	$57	52	99	291	66.0
5	New case-carbonizing compound No. 14	$90	35	96	282	64.0
6	Old case-carbonizing compound No. 14	$90	35	110	324	73.5
7	New case-carbonizing compound No. 17	$40	51	114	336	76.0
8	Old case-carbonizing compound No. 17	$40	51	76	223	50.5
9	Case-carbonizing compound No. 15	$80	45	112	330	74.5
10	Case-carbonizing compound No. 11	$40	..	143	424	95.5
11	Case-carbonizing compound No. 16	...	..	150	442	100.0

treatment, a compound should be selected which gives a high maximum carbon content.

e When parts are produced which require resistance to shock after heat treatment, a compound should be selected which gives a carbon maximum sufficient for the hardness desired and not in excess of this amount, or brittleness will result.

f The ideal case-hardening compound, as indicated by the experiment, would possess the following characteristics: (1) large volume per ton; (2) small shrinkage per run; (3) high resistivity to change of shape or powdering; (4) cleanliness and freedom from dust; (5) uniform case-carbonizing power at all runs; (6) capability of being used an innumerable number of times.

48 These specifications may seem impossible for any compound. There is now on the market, however, a material which can be used over and over again without loss of carbonizing power, by the addition of new material, which fulfils the conditions mentioned.

EXPERIMENT NO. 6

EXPERIMENT OF THE THERMAL CONDUCTIVITY OF CARBONIZING MATERIALS

49 The object of this experiment was to determine the relative rapidity with which different carbonizing materials would heat up. This factor is of great practical importance in determining the length of time required for the carbonizing operation, inasmuch as previous experiments have shown that, using standard round carbonizing pot 9 in. in diameter and 15 in. high and carbonizing material No. 1, more than two-thirds of the total time needed to attain a depth of 1-32 in. of case under regular carbonizing practice is required in heating up the pot and contents to the carbonizing temperature. It will readily be seen that a saving in time in bringing the contents of the pot up to heat will materially decrease the cost of carbonizing operation.

50 The materials used in conducting this experiment were case-carbonizing materials Nos. 1, 8, 11, 14, 15 and 16. The materials were obtained as samples from the various manufac-

turers. In carrying out the experiment the plan was to heat a lead bath to a constant temperature and to record the time for a thermo-couple in a special pot to come up to some definite temperature. The pot was packed with the different carbonizing mediums. The lead pot was 24 in. long, 15 in. wide, and 7 in. deep, and was filled with lead to a depth so that when the pot containing the carbonizer was immersed in it, the lead stood within ½ in. of the top. The temperature of the lead pot was recorded by a calibrated Le Chatelier thermo-couple. The lead pot was covered by a sheet of steel ¼ in. thick, and containing holes to accommodate the carbonizer pot and thermo-couple tube. The pot containing the carbonizer was made of 6 in. round pipe, ¼ in. wall, and 8½ in. high. A plug ¼ in. thick was welded in the bottom. Angle-iron handles were riveted to opposite sides by means of which the pot was held down in the lead bath. The handles were so located that they held the pot immersed to a depth of 5½ in. in the lead. The temperature of the inside of the pot was recorded by a calibrated Le Chatelier thermo-couple so located that the hot junction was equidistant from the bottom and sides of the pot. Both thermo-couples were connected up to read on the H. H. Franklin Company's single pivot galvanometer through a double throw switch. The temperature of the cold junction of the couples was recorded.

51 In packing the pot with the different carbonizing materials it was filled up level full, after locating the thermo-couple properly, and then tamped in fairly tight. The pot was covered with a thin sheet steel cover containing a hole for the thermo-couple tube and this cover was luted on the clay. Records were taken of the time of putting the packed pot in the lead and every five minutes thereafter of the pot and lead temperatures until the former reached 1200 deg. fahr. The recorded temperatures were corrected for cold junction temperature and the calibration correction and time temperature curves were drawn for all the compounds used.

52 The results of this experiment are summarized in Figs. 16 and 17, which give the numbers of the compounds upon which results are recorded, the time required to heat to 1200 deg. with each compound and the rapidity of rise in temperature shown by the thermo-couple packed in the different carbonizing compounds.

CONCLUSIONS

53 This experiment has served to place the different case-carbonizing materials in a definite order in regard to their rapidity of heating up to case-carbonizing temperatures. The thermal conductivity of case-carbonizing materials must be carefully considered when low cost for this operation is essential and when large section pots are used. The lag in pots of large section is often sufficient to produce very un-uniform penetration and thus cause greatest warpage and physical variation.

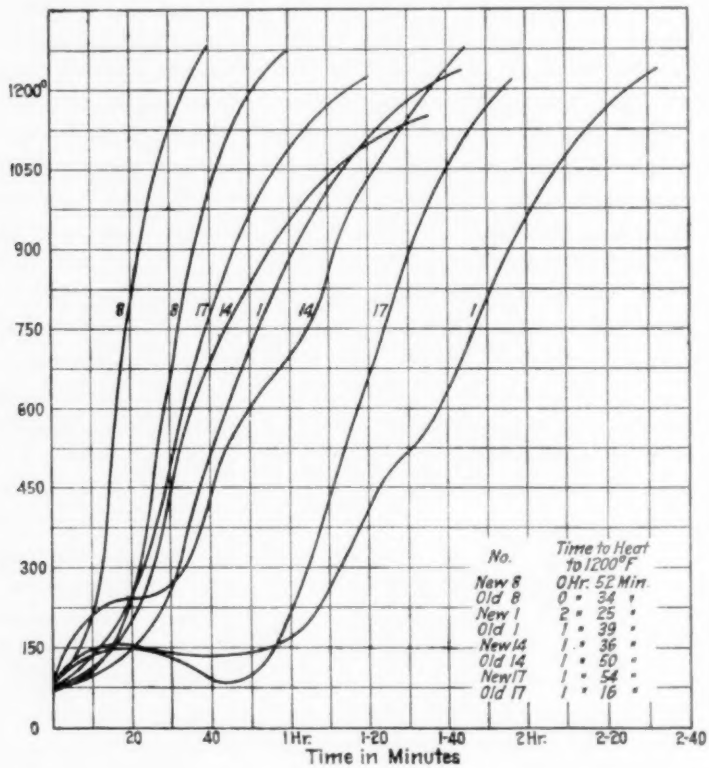

Fig. 16 Thermal Conductivity of Carbonizing Compounds

EXPERIMENT NO. 7

EFFICIENCY OF COPPER PLATING IN PREVENTING CARBONIZATION: GENERAL METHOD

54 The object of the experiment was to determine the efficiency of different thicknesses of copper plate in preventing absorption of carbon, and to ascertain the condition under which a plate could be obtained effectually to prevent carbonization.

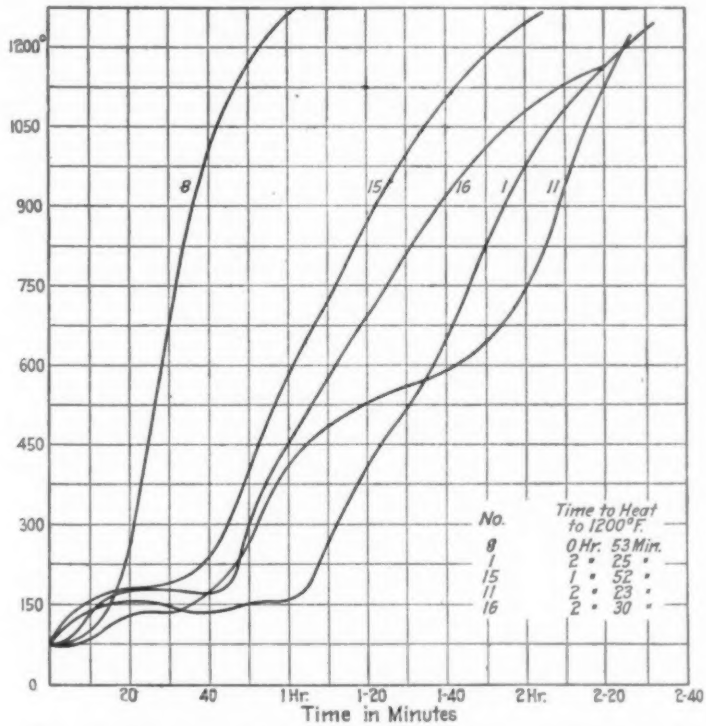

Fig. 17 Thermal Conductivity of Carbonizing Compounds

55 The stock used in the test pieces was steel No. 3 (0.20 per cent carbon basic open-hearth steel). The test pieces were 3½ in. long by 0.450 in. in diameter. They were set up on centers in a lathe and turned to 0.460 in. They were then ground to 0.450 in. and micrometered carefully to 1-10,000 in. All micrometer measurements were made by the same man.

56 The pieces were then copper plated, all conditions of the operation being kept constant except the actual time of plating,

which was carefully noted in each case. After plating the test pieces were micrometered and the thickness of the plate determined. The pieces were then carbonized under standard condition to give a depth of case of 1-32 in. Carbonizing furnace No. 2 was used and the material was case-carbonizing material

TABLE 11 MEASUREMENT[1] OF TEST PIECES; DURATION OF PLATING OPERATION; PER CENT CARBON ABSORBED

No.	Diameter before Copper Plating	Second Length Time in Plating Bath, Sec.	Diameter after Copper Plate	Thickness of Copper Plating
1	0.4496	about 1	0.4497	0.00005
2	0.4500	10	0.4501	0.00005
3	0.4500–0.4498	20	0.4501–0.4499	0.00005
4	0.4502	30	0.4503	0.00005
5	0.4501	60	0.4504	0.00015
6	0.4496	2	0.4500	0.0002
7	0.4500–0.4502	3	0.4507–0.4508	0.0003
8	0.4500	4	0.4509	0.00045
9	0.4499	5	0.4512–0.4509	0.00065–0.0005
10	0.4500	10	0.4525–0.4516	0.00125–0.0008

No.	Diameter after Removal of Copper	Thickness Metal Removed on Radius	Per Cent C Cut No. 1	Per Cent C Cut No. 2
1	0.450 (?)	....	0.96	0.95
2	0.4504–0.450 (?)	....	0.58	0.56
3	0.4499–0.4498	0.0002–0.0001	0.40	0.38
4	0.450	0.0003	0.46	0.42
5	0.4498	0.0006	0.20	0.18
6	0.4492–0.4490	0.0008–0.001	0.19	0.17
7	0.4496–0.4498	0.0013–0.001	0.18	0.16
8	0.4493–0.4494	0.0016–0.0015	0.20	0.18
9	0.4494–0.4492	0.0018–0.0016	0.17	0.16
10	0.4495–0.4490	0.003 –0.0026	0.17	0.16

[1] All measurements made by one man and as carefully as possible with a 0.0001 in. micrometer

No. 1, one-half new and one-half used. The pieces were then set up in a lathe and the copper plate removed with emery cloth, after which they were carefully micrometered again.

57 Two cuts were taken on each test piece, each cut being 0.005 in. on the radius, reducing the diameter 0.010 in. The turnings obtained were carefully taken and were very fine. Carbon determinations by direct combustion were made on each cut.

58 Direct electric current for all plating operations was

furnished by a 4-pole direct-current dynamo which is belt driven by an alternating-current constant speed motor. The rated capacity of the dynamo is 360 amperes at 6 volts.

Voltage across terminals	4.1
Temperature of bath	170 deg. fahr.

Operation No.	Contents of Bath	Purpose
1	Gasolene	To remove grease
2	Sawdust	To dry
3	Warm potassium hydroxide solution	To remove grease and dirt
4	Warm water	To wash
5	Warm sulphuric acid solution	To acid clean
6	Warm water	To wash
7	Cold water	Additional wash
8	Cold potassium cyanide solution	Cleanser
9	Cold water	To wash
10	Electric cleaner, warm sodium hydroxide case-iron anode	Cleanser to give good plating surface
11	Copper plating bath of copper sulphate and potassium cyanide solution warm	Plating bath

59 The copper cover to prevent the penetration entirely must have a thickness of 0.0005 in. Microscopic inspection before and after case carbonizing of copper plated pieces of steel showed that the copper coating was not continuous when the thickness was less than 0.0005 in.

GENERAL CONCLUSIONS

60 This paper may lack interest for the more scientific reader on account of the non-technical nature of the notes, and the want of timely information on the subject of case carbonizing. The information herein presented was obtained with the object of pointing out: (*a*) the quantitative effect of the commercial irregularities which creep into case-carbonized steel parts; (*b*) the precautions which must be observed if uniformity is desired; and (*c*) the physical characteristics in case-carbonizing materials which must be considered if low cost for this operation is to be obtained.

61 The ideal case-carbonizing compound perhaps has not yet been produced; however, compounds which are clean, mechanically strong, uniform in case-carbonizing power, and capable of unlimited re-use are being commercially employed in case-carbonizing operation. This is substantial progress.

ACKNOWLEDGMENTS

62 The researches are the results of several years' study and the product of the efforts of more than one man. Messrs. Fenner, Baxter, Nead and Kiefer, members of the metallurgical staff of the H. H. Franklin Manufacturing Company, Mr. Bourg, metallurgist for the Brown Lipe Chapin Company, and Messrs. H. J. Stagg and C. R. Bulley of the author's staff in the metallurgical department of the Halcomb Steel Company have all contributed their share to the results herein reported and it was only by the coöperation of all that the vast amount of work necessary could be accomplished in so short a time. The author wishes, therefore, to thank these gentlemen and to credit them with their share in the work here reported. The author also wishes to thank Dr. Mathews, manager of the Halcomb Steel Company, for his advice and support. The companies served by the compilers of these data deserve recognition for their progressiveness and their contribution to the general knowledge of the subject in permitting the publication of this report. The subjects of interest connected with the commercial use of steels are so large that it is only by such coöperation that a great deal can be accomplished in a few years.

APPENDIX NO. 1

TEMPERATURES AT WHICH TEST PIECES WERE REHEATED OR ANNEALED, EXPERIMENT NO. 1

TABLE 12 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 2

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Quenched from pot at 1500° into water	0.500	900	0.40	0.04
2	Reheat 1400°, quench in water	0.500	775	0.30	0.04
3	Reheat 1500°, quench in water	0.500	740	0.23	0.04
4	Reheat 1600°, quench in water	0.500	850	0.24	0.04
5	Reheat 1700°, quench in water	0.500	800	0.24	0.04
6	Reheat 1800°, quench in water	0.500	815	0.24	0.04
7	Reheat 1600°, quench oil, reheat 1400°, quench water	0.499	750	0.29	0.04
8	Reheat 1600°, quench oil, reheat 1500°, quench oil	0.499	1050	0.50	0.04
9	Reheat 1600°, quench oil, reheat 1500°, quench water	0.500	1000	0.50	0.04
10	Reheat 1500°, quench water, draw 380° for 20 nim.	0.501	820	0.24	0.04
11	Anneal 1400°, reheat 1500°, quench water	0.500	830	0.30	0.04
12	Anneal 1600°, quench oil, reheat 1500°, quench water	0.499	900	0.37	0.04

SUMMARY: 1, Best single heat treatment reheat 1600°, quench water; 2, best double heat treatment reheat 1600°, quench oil, reheat 1500°, quench oil; 3, best double heat treatment increases strength 23 per cent and increases toughness 105 per cent; 4, drawing the temper increases strength 10 per cent and toughness 3 per cent; 5, annealing increases (wirh single treatment) strength 12 per cent, toughness 25 per cent; 6, annealing decreases (with double treatment) strength 10 per cent, toughness 26 per cent.

TABLE 13 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 3

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1500°, quench in water	0.500	1020	0.61	0.010
2	Reheat 1500°, quench in water	0.500	950	0.44	0.020
3	Reheat 1500°, quench in water	0.500	940	0.29	0.025
4	Reheat 1500°, quench in water	0.500	850	0.31	0.030
5	Reheat 1500°, quench in water	0.500	800	0.30	0.035
6	Reheat 1500°, quench in water	0.500	725	0.24	0.040
7	Quenched from pot at 1500°, in water	0.501	940	0.30	0.040
8	Reheat 1400°, quench in water	0.501	700	0.21	0.040
9	Reheat 1500°, quench in water	0.500	700	0.22	0.040
10	Reheat 1600°, quench in water	0.500	810	0.24	0.040
11	Reheat 1700°, quench in water	0.500	810	0.25	0.040
12	Reheat 1800°, quench in water	0.500	810	0.24	0.040
13	Reheat 1600°, quench oil, reheat 1400°, quench water	0.499	840	0.30	0.040
14	Reheat 1600°, quench oil, reheat 1500°, quench oil	0.498	1000	0.39	0.040
15	Reheat 1600°, quench oil, reheat 1500°, quench water	0.499	970	0.36	0.040
16	Reheat 1500°, quench water, draw 380° for 20 min.	0.500	870	0.26	0.040
17	Anneal 1400°, reheat 1500°, quench water	0.500	845	0.26	0.040
18	Anneal 1600°, reheat 1600°, quench oil, reheat 1500°, quench water	0.500	830	0.26	0.040

Summary: 1, Strength and toughness decrease with increasing depth of case; 2, minimum strength and toughness with 0.040 in. depth of case; 3, best single heat treatment, reheat 1600 deg. fahr., quench water; 4, best double heat treatment, reheat 1600 deg. fahr., quench oil, reheat 1500 deg. fahr., quench oil; 5, double heat treatment increases strength 25 per cent, toughness 56 per cent; 6, drawing temper at 380 deg. fahr. increases strength 21 per cent, toughness 4 per cent; 7, annealing and single treatment increases strength 16.5 per cent, toughness 4 per cent; 8, annealing and double treatment decreases strength 14.5 per cent, toughness 29 per cent.

TABLE 14 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 4

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1500°, quench water	0.500	830	0.48	0.010
2	Reheat 1500°, quench water	0.500	820	0.43	0.015
3	Reheat 1500°, quench water	0.500	740	0.35	0.020
4	Reheat 1500°, quench water	0.500	745	0.34	0.025
5	Reheat 1500°, quench water	0.500	725	0.32	0.030
6	Reheat 1500°, quench water	0.500	700	0.22	0.040
7	Quenched from pot at 1500° in water	0.500	810	0.24	0.040
8	Reheat 1400°, quench water	0.500	670	0.22	0.040
9	Reheat 1500°, quench water	0.500	700	0.22	0.040
10	Reheat 1600°, quench water	0.501	850	0.25	0.040
11	Reheat 1700°, quench water	0.500	830	0.25	0.040
12	Reheat 1800°, quench water	0.500	810	0.24	0.040
13	Reheat 1600°, quench oil, reheat 1400°, quench water	0.500	840	0.30	0.040
14	Reheat 1600°, quench oil, reheat 1500°, quench water	0.500	950	0.45	0.040
15	Reheat 1500°, quench water, draw 380° for 20 min.	0.500	790	0.26	0.040
16	Reheat 1600°, quench oil, reheat 1500°, quench water, draw 380° for 20 min.	0.500	950	0.44	0.040
17	Anneal 1400°, reheat 1500°, quench water	0.500	800	0.26	0.040

SUMMARY: 1, Strength and toughness decrease with increasing depth of case; 2, minimum strength and toughness occur with depth of case of 0.020 in.; 3, best single heat treatment reheat 1600 deg. fahr., quench water; 4, best double heat treatment reheat 1600 deg. fahr., quench oil, reheat 1500 deg. fahr., quench water; 5, double heat treatment increases strength 11.8 per cent, toughness 80 per cent; 6, drawing increases with single treatment strength 12.9 per cent, toughness 18.2 per cent; 7, drawing increases with double treatment strength 0 per cent, toughness 0 per cent; 8, annealing increases with single treatment strength 14.3 per cent, toughness 18.2 per cent.

TABLE 15 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 5

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1550°, quench oil	0.508	1225	2.66	0.014
2	Reheat 1550°, quench oil	0.508	1220	2.30	0.020
3	Reheat 1550°, quench oil	0.509	1215	1.75	0.025
4	Reheat 1550°, quench oil	0.509	1360	1.20	0.030
5	Reheat 1550°, quench oil	0.508	1295	0.70	0.035
6	Reheat 1550°, quench oil	0.509	1255	0.46	0.040
7	Quenched from pot at 1500° into oil	0.505	1400	0.53	0.040
8	Reheat 1310°, quench oil	0.504	850	0.46	0.040
9	Reheat 1400°, quench oil	0.504	1150	0.46	0.040
10	Reheat 1500°, quench oil	0.504	1250	0.46	0.040
11	Reheat 1600°, quench oil	0.504	1250	0.45	0.040
12	Reheat 1700°, quench oil	0.504	1280	0.46	0.040
13	Reheat 1800°, quench oil	0.504	1250	0.43	0.040
14	Reheat 1600°, quench oil, reheat 1400°, quench oil	0.504	1210	0.60	0.040
15	Reheat 1600°, quench oil, reheat 1400°, quench water	0.502	1200	0.42	0.040
16	Reheat 1600°, quench oil, reheat 1500°, quench oil	0.503	1500	0.51	0.040
17	Reheat 1600°, quench oil, reheat 1500°, quench water	0.504	1240	0.44	0.040
18	Reheat 1500°, quench oil, draw 380° for 20 min.	0.504	1560	0.56	0.040
19	Reheat 1600°, quench oil, reheat 1400°, draw 380° for 20 min.	0.504	1320	0.72	0.040
20	Anneal 1500°, reheat 1500°, quench oil	0.504	1280	0.43	0.040
21	Reheat 1500°, reheat 1600°, quench oil, reheat 1400°, quench oil	0.505	1200	0.60	0.040

SUMMARY: 1, Strength and toughness decrease with increase depth of case; 2, minimum strength and toughness occur with depth of case 0.040 in.; 3, best single heat treatment reheat 1500°, quench oil; 4, best double heat treatment reheat 1600°, quench oil, reheat 1500°, quench oil; 5, double heat treatment increases strength 20 per cent, toughness 10.8 per cent; 6, drawing increases with single heat treatment strength 24.8 per cent, toughness 10.8 per cent; 7, drawing increases with double heat treatment strength 9.1 per cent, toughness 20 per cent; 8, annealing increases with single heat treatment strength 2.4 per cent, toughness 6.5 per cent; 9, annealing increases with double heat treatment strength 0 per cent, toughness 0 per cent.

TABLE 16 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 6

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1500°, quench oil	0.504	2010	2.40	0.010
2	Reheat 1500°, quench oil	0.504	1675	0.79	0.015
3	Reheat 1500°, quench oil	0.505	1615	0.69	0.020
4	Reheat 1500°, quench oil	0.505	1455	0.55	0.030
5	Reheat 1500°, quench oil	0.505	1390	0.52	0.035
6	Reheat 1500°, quench oil	0.504	1250	0.43	0.040
7	Quenched from pot at 1500° into oil	0.504	1350	0.49	0.040
8	Reheat 1300°, quench oil	0.503	880	0.32	0.040
9	Reheat 1400°, quench oil	0.503	1230	0.42	0.040
10	Reheat 1500°, quench oil	0.504	1315	0.45	0.040
11	Reheat 1600°, quench oil	0.504	1300	0.45	0.040
12	Reheat 1700°, quench oil	0.502	1320	0.45	0.040
13	Reheat 1800°, quench oil	0.502	1300	0.45	0.040
14	Reheat 1600°, quench oil, reheat 1300°, quench oil	0.503	1240	0.75	0.040
15	Reheat 1600°, quench oil, reheat 1400°, quench oil	0.505	1260	0.59	0.040
16	Reheat 1600°, quench oil, reheat 1400°, quench water	0.504	1200	0.37	0.040
17	Reheat 1600°, quench oil, reheat 1500°, quench oil	0.504	1390	0.44	0.040
18	Reheat 1600°, quench oil, reheat 1500°, quench water	0.504	1415	0.46	0.040
19	Reheat 1500°, quench oil, draw 380° for 20 min.	0.504	1610	0.53	0.040
20	Reheat 1600°, quench oil, reheat 1400°, quench oil, draw 380° for 20 min.	0.504	1400	0.65	0.040
21	Anneal 1500°, quench oil	0.504	1370	0.44	0.040
22	Anneal 1600°, quench oil, reheat 1400°, quench oil	0.504	1250	0.60	0.040

SUMMARY: 1, Strength and toughness decreases with increasing depth of case; 2, minimum strength and toughness occurs with depth of case of 0.040 in.; 3, best single heat treatment reheat 1500 deg. fahr., quench in oil; 4, best double heat treatment reheat 1600 deg. fahr., quench in oil, reheat 1500 deg. fahr., quench oil; 5, best double heat treatment increases strength 6.1 per cent and toughness 0 per cent; 6, drawing increases with single treatment strength 23 per cent and toughness 17.8 per cent; 7, drawing increases with double treatment strength 11 per cent and toughness 10.1 per cent; 8, annealing increases with single treatment strength 4.1 per cent and toughness 0 per cent; 9, annealing increases with double treatment strength 0 per cent and toughness 0 per cent.

TABLE 17 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 7

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1500°, quench oil	0.505	1975	2.50	0.010
2	Reheat 1500°, quench oil	0.505	1940	1.25	0.020
3	Reheat 1500°, quench oil	0.505	1760	0.96	0.025
4	Reheat 1500°, quench oil	0.506	1640	0.70	0.030
5	Reheat 1500°, quench oil	0.504	1410	0.53	0.035
6	Reheat 1500°, quench oil	0.505	1275	0.44	0.040
7	Quench from pot at 1500° into oil	0.504	1250	0.42	0.040
8	Reheat 1300°, quench oil	0.501	1000	0.33	0.040
9	Reheat 1400°, quench oil	0.500	1250	0.40	0.040
10	Reheat 1500°, quench oil	0.502	1280	0.44	0.040
11	Reheat 1600°, quench oil	0.502	1280	0.44	0.040
12	Reheat 1700°, quench oil	0.499	1300	0.45	0.040
13	Reheat 1800°, quench oil	0.499	1225	0.42	0.040
14	Reheat 1600°, quench oil, reheat 1300°, quench oil	0.501	1200	0.60	0.040
15	Reheat 1600°, quench oil, reheat 1400°, quench oil	0.500	1320	0.50	0.040
16	Reheat 1600°, quench oil, reheat 1400°, quench water	0.500	1170	0.37	0.040
17	Reheat 1600°, quench oil, reheat 1500°, quench oil	0.500	1380	0.41	0.040
18	Reheat 1600°, quench oil, reheat 1500°, quench water	0.500	1250	0.40	0.040
19	Reheat 1500°, quench oil, draw 380° for 20 min	0.503	1630	0.53	0.040
20	Reheat 1600°, quench oil, reheat 1400°, quench oil, draw 380° for 20 min	0.502	1525	0.58	0.040
21	Anneal 1500°, reheat 1500°, quench oil	0.502	1300	0.40	0.040
22	Anneal 1500°, reheat 1600°, quench oil, reheat 1400°, quench oil	0.502	1300	0.47	0.040

SUMMARY: 1, Toughness and strength decrease with increasing depth of case; 2, minimum strength and toughness occurs with depth of case of 0.040 in.; 3, best single heat treatment reheat 1450 deg. fahr., quench oil; 4, best double heat treatment reheat 1600 deg. fahr., reheat 1400 deg. fahr., quench oil; 5, best double heat treatment increases strength 5.6 per cent and toughness 13.6 per cent; 6, drawing increases with single treatment, strength 27.4 per cent, and toughness 20.5 per cent; 7, drawing increases with double treatment, strength 15.5 per cent, and toughness 16 per cent; 8, annealing increases with single treatment, strength 4 per cent, and toughness 0 per cent; 9, annealing decreases with double treatment, strength 1.5 per cent, and toughness 6 per cent.

TABLE 18 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 8

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1550°, quench oil	0.507	2055	1.14	0.010
2	Reheat 1550°, quench oil	0.508	1625	0.55	0.020
3	Reheat 1550°, quench oil	0.507	1375	0.43	0.040
4	Reheat 1550°, quench oil	0.507	1350	0.42	0.060
5	Reheat 1550°, quench oil	0.506	1350	0.42	0.070
6	Reheat 1550°, quench oil	0.506	1350	0.42	0.095
7	Quenched from pot at 1500° into oil	0.506	1350	0.45	0.040
8	Reheat 1300°, quench oil	0.503	800	0.28	0.040
9	Reheat 1400°, quench oil	0.504	1100	0.34	0.040
10	Reheat 1500°, quench oil	0.503	1250	0.40	0.040
11	Reheat 1600°, quench oil	0.504	1300	0.43	0.040
12	Reheat 1700°, quench oil	0.506	1360	0.44	0.040
13	Reheat 1800°, quench oil	0.504	1250	0.41	0.040
14	Reheat 1550°, quench oil, reheat 1300°, quench oil	0.504	1300	0.48	0.040
15	Reheat 1550°, quench oil, reheat 1400°, quench oil	0.505	1450	0.50	0.040
16	Reheat 1550°, quench oil, reheat 1400°, quench water	0.505	1400	0.39	0.040
17	Reheat 1550°, quench oil, reheat 1500°, quench oil	0.504	1440	0.49	0.040
18	Reheat 1550°, quench oil, reheat 1500°, quench water	0.502	1340	0.37	0.040
19	Reheat 1550°, quench oil, draw 380° for 20 min	0.503	1750	0.60	0.040
20	Reheat 1500°, quench oil, reheat 1400°, quench oil, draw 380° for 20 min	0.505	1580	0.53	0.040
21	Anneal 1500°, reheat 1500°, quench oil	0.504	1370	0.43	0.040
22	Anneal 1500°, reheat 1550°, quench oil, reheat 1400°, quench oil	0.505	1440	0.46	0.040

SUMMARY: 1, Strength and toughness decrease with increase in depth of case; 2, minimum strength and toughness occur with depth of case 0.040 in.; 3, best single treatment reheat 1500°, quench oil; 4, best double treatment reheat 1550°, quench oil, reheat 1400°, quench oil; 5, best double treatment increases strength 6.9 per cent, toughness 19 per cent; 6, drawing increases with best single treatment, strength 29.6 per cent, toughness 43 per cent; 7, drawing increases with best double treatment 17 per cent, toughness 23.8 per cent; 8, annealing increases with best single treatment 1.5 per cent, toughness 2.4 per cent; 9, annealing decreases with best double treatment, strength 0.7 per cent, toughness 8 per cent.

TABLE 19 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 9

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1500°, quench oil	0.508	1595	0.52	0.010
2	Reheat 1500°, quench oil	0.508	1450	0.46	0.020
3	Reheat 1500°, quench oil	0.509	1450	0.48	0.040
4	Reheat 1500°, quench oil	0.509	1455	0.45	0.060
5	Reheat 1500°, quench oil	0.508	1435	0.47	0.070
6	Reheat 1500°, quench oil	0.509	1400	0.44	0.095
7	Quenched from pot at 1500° into oil	0.504	1700	0.50	0.040
8	Reheat 1300°, quench oil	0.507	1075	0.44	0.040
9	Reheat 1400°, quench oil	0.507	1450	0.44	0.040
10	Reheat 1500°, quench oil	0.507	1450	0.47	0.040
11	Reheat 1600°, quench oil	0.504	1450	0.48	0.040
12	Reheat 1700°, quench oil	0.503	1500	0.50	0.040
13	Reheat 1800°, quench oil	0.503	1500	0.50	0.040
14	Reheat 1550°, quench oil, reheat 1300°, quench oil	0.504	1300	0.47	0.040
15	Reheat 1550°, quench oil, reheat 1400°, quench oil	0.505	1550	0.47	0.040
16	Reheat 1550°, quench oil, reheat 1400°, quench water	0.506	1170	0.32	0.040
17	Reheat 1550°, quench oil, reheat 1500°, quench oil	0.506	1450	0.46	0.040
18	Reheat 1550°, quench oil, reheat 1500°, quench water	0.503	1240	0.34	0.040
19	Reheat 1550°, quench oil, draw 380° for 20 min	0.506	1950	0.60	0.040
20	Reheat 1560°, quench oil, reheat 1400°, quench oil, draw 380° for 20 min	0.506	1950	0.62	0.040
21	Anneal 1500°, reheat 1500°, quench oil	0.506	1500	0.48	0.040
22	Anneal 1500°, reheat 1550°, quench oil, reheat 1400°, quench oil	0.506	1500	0.48	0.040

SUMMARY: 1, The strength and toughness decreases with increase in depth of case; 2, minimum strength and toughness occur with depth of case of 0.02 in.; 3, best single treatment reheat 1400°, quench oil; 4, best double treatment reheat 1500°, quench oil, reheat 1400°, quench oil; 5, best double treatment increases strength 6.9 per cent and toughness 0 per cent; 6, drawing increases with single treatment, strength 34.4 per cent, toughness 27.6 per cent; 7, drawing increases with double treatment strength 25.8 per cent, toughness 40.5 per cent; 8, annealing increases with single treatment, strength 4.1 per cent, toughness 2.1 per cent; 9, annealing decreases with double treatment, strength 3.3 per cent, toughness 0 per cent.

TABLE 20 TRANSVERSE TESTS OF CASE-CARBONIZED STEEL NO. 10

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Depth of Case in in.
1	Reheat 1700°, quench water	0.505	1700	1.04	0.105
2	Reheat 1700°, quench water	0.507	1630	0.85	0.020
3	Reheat 1700°, quench water	0.505	1600	0.72	0.025
4	Reheat 1700°, quench water	0.508	1550	0.54	0.030
5	Reheat 1700°, quench water	0.507	1410	0.42	0.035
6	Reheat 1700°, quench water	0.510	1385	0.42	0.040
7	Quenched from pot at 1700°	0.506	1490	0.49	0.040
8	Reheat 1400°, quench water	0.506	1150	0.53	0.040
9	Reheat 1500°, quench water	0.506	1200	0.40	0.040
10	Reheat 1600°, quench water	0.506	1400	0.40	0.040
11	Reheat 1700°, quench water	0.506	1400	0.42	0.040
12	Reheat 1800°, quench water	0.506	1390	0.41	0.040
13	Reheat 1700°, quench oil, reheat 1400°, quench water	0.504	1300	1.60	0.040
14	Reheat 1700°, quench oil, reheat 1500°, quench water	0.503	1240	0.38	0.040
15	Reheat 1700°, quench oil, reheat 1600°, quench oil	0.502	1550	0.67	0.040
16	Reheat 1700°, quench oil, reheat 1600°, quench water	0.504	1500	0.44	0.040
17	Reheat 1700°, quench oil, reheat 1700°, quench oil	0.504	1500	0.49	0.040
18	Reheat 1700°, quench oil, reheat 1700°, quench water	0.503	1450	0.48	0.040
19	Reheat 1700°, quench water, draw at 380° for 20 min.	0.504	1600	0.50	0.040
20	Reheat 1700°, quench oil, reheat 1600°, quench water, draw 380° for 20 min.	0.504	1750	0.50	0.040
21	Anneal 1550°, reheat 1700°, quench water	0.504	1440	0.43	0.040

Summary: 1, Strength and toughness decrease with increase in depth of case; 2, minimum strength and toughness occur with depth of case of 0.035 per cent; 3, best single heat treatment reheat 1600 deg. fahr. to 1700 deg. fahr., quench water; 4, best double heat treatment reheat 1700 deg. fahr., quench oil, reheat 1600 deg. fahr., quench oil; 5, best double heat treatment increases strength 10.7 per cent, toughness 92.5 per cent; 6, drawing increases with single treatment, strength 14.3 per cent, toughness 25 per cent; 7, drawing increases with double treatment, strength 16.7 per cent, toughness 13.6 per cent; 8, annealing increases with single treatment, strength 2.8 per cent, toughness 7 per cent.

TABLE 21 TRANSVERSE TESTS ON OIL-HARDENED STEELS

STEEL No. 11

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Hardness	Remarks
1	Heated 1700°, quench in oil, drawn 212° for 20 min.	508	2000	0.75	576	....
2	Heated 1700°, quench in oil, drawn 400° for 20 min.	508	3025	1.55	542	....
3	Heated 1700°, quench in oil, drawn 600° for 20 min.	508	2375	2.50	508	Did not break

STEEL No. 12

No.	Heat Treatment	Size in in.	Load in lb. at Rupture	Deflection of Center at Rupture in in.	Hardness	Remarks
1	Heated 1500°, quenched in oil, drawn 212° for 20 min.	508	1900	0.60	562	....
2	Heated 1500°, quenched in oil, drawn 400° for 20 min.	508	2825	1.50	545	....
3	Heated 1500°, quenched in oil, drawn 600° for 20 min.	508	2470	2.50	513	Did not break

APPENDIX NO. 2

TEMPERATURE RECORDS FOR EXPERIMENT NO. 3

TABLE 22 TEMPERATURE RECORD RUN NO. 1, 1300 DEG. FAHR. MATERIAL: BAR 291-2 (0.20% CARBON OPEN HEARTH); BAR 726-2 (0.20% NICKEL); BAR 353-2 (0.20% "A" VANADIUM)

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
9.17	90	100	atmos.	....	Furnace started
9.30	97	530	....	....	
9.45	98	880	....	....	
10.00	106	1035	....	....	
10.15	110	1240	490	475	
10.30	106	1400	870	855	
10.45	104	1335	1200	1185	
11.00	108	1320	1310	1295	Begin to count time
11.15	112	1220	1320	1300	
11.30	114	1160	1300	1280	
11.45	118	1225	1260	1240	
12.00	112	1320	1280	1260	
12.15	116	1355	1330	1310	
12.30	...	1360	1330	1310	
12.45	...	1280	1350	1320	
1.00	117	1285	1360	1340	
1.15	118	1255	1330	1310	
1.30	124	1290	1320	1295	
1.45	122	1300	1320	1295	
2.00	117	1255	1335	1315	
2.15	121	1225	1315	1295	
2.30	124	1225	1290	1265	
2.45	124	1345	1310	1280	
3.00	132	1340	1360	1330	
3.15	128	1260	1360	1335	
3.30	120	1200	1330	1305	
3.45	117	1200	1300	1280	
4.00	126	1250	1270	1245	Pot pulled

TABLE 23 TEMPERATURE RECORD RUN NO. 2, 1400 DEG. FAHR.

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
8.55	95	400	....	....	Furnace started
9.05	98	500	....	....	
9.15	95	840	....	....	
9.30	100	1040	....	....	
9.45	103	1190	....	....	
10.00	105	1325	715	700	
10.15	105	1445	1150	1135	
10.30	110	1440	1330	1315	
10.45	110	1460	1440	1425	Begin to count time
11.00	112	1400	1460	1440	
11.15	116	1360	1440	1420	
11.30	119	1335	1415	1395	
11.45	114	1385	1410	1390	
12.00	125	1435	1440	1415	
12.15	123	1420	1465	1440	
12.30	120	1400	1460	1435	
12.45	120	1380	1420	1400	
1.00	120	1415	1415	1395	
1.15	125	1345	1400	1375	
1.30	124	1355	1400	1375	
1.45	130	1435	1425	1400	
2.00	130	1440	1450	1425	
2.15	125	1405	1445	1420	
2.30	126	1375	....	....	No. 4 couple off
2.45	...	1320	....	....	
3.00	128	1300	1310	1285	
3.15	132	1410	1325	1290	
3.30	125	1475	1400	1375	
3.45	120	1460	1430	1405	
4.00	125	1420	1425	1400	
4.15	125	1375	1405	1380	Pot pulled

TABLE 24 TEMPERATURE RECORD RUN NO. 3, 1500 DEG. FAHR. MATERIAL: BAR 292-2 (0.20% CARBON OPEN HEARTH); BAR 728-2 (0.20% NICKEL); BAR 354-2 (0.27% "A" VANADIUM)

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
8.40	...	150	....	....	Furnace started
9.00	98	650	....	....	
9.15	98	910	....	....	
9.30	101	1090	....	....	
9.45	101	1230	490	475	
10.00	103	1345	910	895	
10.15	106	1440	1190	1175	
10.30	110	1535	1385	1370	
10.45	111	1540	1520	1505	
11.00	112	1540	1570	1550	
11.15	120	1500	1535	1515	
11.30	121	1465	1565	1540	
11.45	118	1460	1525	1505	
12.00	116	1455	1545	1520	
12.15	120	1400	1520	1500	
12.30	120	1360	1280 (?)	1260 (?)	
12.45	120	1420	1400	1380	
1.00	120	1470	1420	1400	
1.15	120	1455	1555	1530	
1.30	126	1370	1530	1505	
1.45	121	1360	1475	1450	
2.00	128	1410	1460	1435	
2.15	132	1480	1525	1495	
2.30	125	1480	1580	1565	
2.45	124	1425	1545	1520	
3.00	128	1380	1510	1485	
3.15	130	1365	1500	1475	
3.30	128	1420	1475	1450	
3.45	122	1500	1520	1496	
4.00	120	1390	1570	1555	
4.15	127	1320	1500	1475	Pot pulled

TABLE 25 TEMPERATURE RECORD RUN NO. 4, 1600 DEG. FAHR. MATERIAL: BAR 293-1 (0.20% CARBON OPEN HEARTH); BAR 732-1 (0.20% NICKEL); BAR 355-1 (0.20% "A" VANADIUM)

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
10.00	...	....	....	....	Furnace started
10.30	...	1000	....	....	
10.45	...	1210	....	....	
11.00	...	....	....	....	
11.15	80	1460	910	895	
11.30	85	1565	1235	1210	
11.45	86	1655	1465	1445	
12.00	88	1655	1600	1580	
12.15	...	....	....	....	
12.30	...	....	....	....	
12.45	...	....	....	....	
1.00	102	1515	1545	1520	
1.15	99	1565	1565	1540	
1.30	101	1530	1550	1525	
1.45	95	1550	1560	1435	
2.00	84	1625	1600	1580	
2.15	102	1650	1635	1610	
2.30	100	1640	1655	1625	
2.45	90	1580	1655	1625	
3.00	74	1585	1640	1675	
3.15	92	1560	1600	1580	
3.30	90	1555	1500	1475	
3.45	105	1540	1565	1540	
4.00	92	1620	1600	1580	
4.15	...	....	....	....	
4.30	96	1655	1650	1625	
4.45	98	1585	1640	1615	
5.00	98	1530	1595	1575	Pot pulled

TABLE 26 TEMPERATURE RECORD RUN NO. 5, 1700 DEG. FAHR. MATERIAL: BAR 293-2 (0.20% CARBON OPEN HEARTH); BAR 732-2 (0.20% NICKEL); BAR 355-2 (0.20% "A" VANADIUM)

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
8.45	...	....	....	....	Furnace started
9.00	...	....	....	....	
9.15	...	1100	....	....	
9.30	...	1300	....	....	
9.45	74	1405	500	980	
10.00	79	1570	980	955	
10.15	76	1700	1375	1330	
10.30	78	1740	1565	1540	
10.45	90	1600	1635	1610	
11.00	88	1590	1610	1590	
11.15	88	1585	1600	1580	
11.30	92	1695	1630	1605	
11.45	102	1800	1740	1725	
12.00	100	1740	1750	1735	
12.15	108	1700	1740	1725	
12.30	...	....	....	....	
12.45	...	....	....	....	
1.00	...	....	....	....	
1.15	91	1650	1665	1650	
1.30	85	1650	1675	1660	
1.45	90	1715	1715	1700	
2.00	91	1685	1720	1705	
2.15	91	1660	1685	1670	
2.30	110	1665	1680	1665	
2.45	90	1665	1685	1670	
3.00	90	1665	1685	1670	
3.15	88	1675	1700	1685	
3.30	104	1675	1680	1665	
3.45	103	1675	1690	1675	
4.00	...	1685	1700	1685	
4.15	100	1695	1705	1690	
4.30	98	1695	1705	1690	
4.45	90	1700	1715	1700	Pot pulled

TABLE 27 TEMPERATURE RECORD RUN NO. 26, 1800 DEG. FAHR. MATERIAL: BAR 284-1 (0.20% CARBON OPEN HEARTH); BAR 469-1 (0.20% NICKEL); BAR 455-1 (0.20% "A" VANADIUM)

Time	Temperature, Deg. Fahr.				Remarks
	Cold Junction	Furnace	Pot	Pot Corrected	
10.00	...	....	....	....	Furnace started
10.15	...	....	....	....	
10.30	...	....	....	....	
10.45	...	1220	....	....	
11.00	...	1380	....	....	
11.15	...	....	....	....	
11.30	88	1620	1215	1200	
11.45	96	1760	1500	1475	
12.00	97	1805	1710	1695	
12.15	109	1810	1780	1780	
12.30	...	....	....	....	
12.45	...	....	....	....	
1.00	108	1865	1870	1860	
1.15	112	1745	1835	1825	
1.30	104	1760	1780	1770	
1.45	106	1805	1810	1800	
2.00	106	1815	1825	1815	
2.15	96	1780	1820	1810	
2.30	...	....	....	....	
2.45	113	1775	1800	1790	
3.00	115	1780	1800	1790	
3.15	105	1780	1805	1795	
3.30	111	1780	1800	1790	
3.45	115	1785	1800	1790	
4.00	102	1785	1805	1795	
4.15	105	1780	1800	1790	
4.30	112	1775	1800	1790	
4.45	101	1770	1795	1785	
5.00	116	1765	1786	1775	Pot pulled

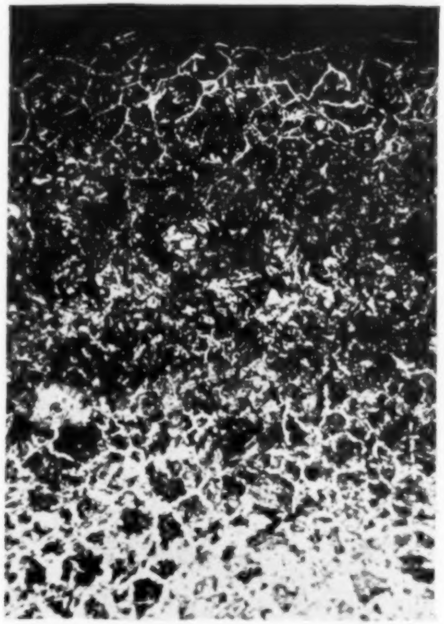

FIG. 18 OPEN HEARTH STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG. FAHR. SHOWS ENTIRE ZONE AFFECTED BY CASE-CARBONIZING OPERATION; 50 DIAMETERS

In comparison with Figs. 28 and 29 note: (a) relatively small carbon penetration; (b) mass of cementite needles in outer zone.

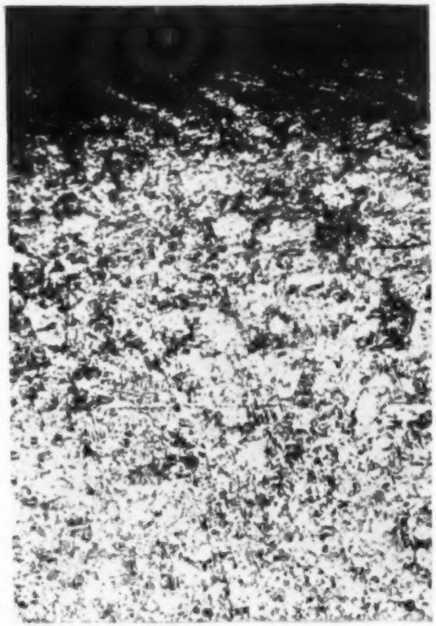

FIG. 19 OPEN HEARTH STEEL, 0.20% CARBON, CASE CARBONIZED AT 1300 DEG. FAHR. SHOWS FERRITE BAND PENETRATING CARBONIZED ZONE; 50 DIAMETERS

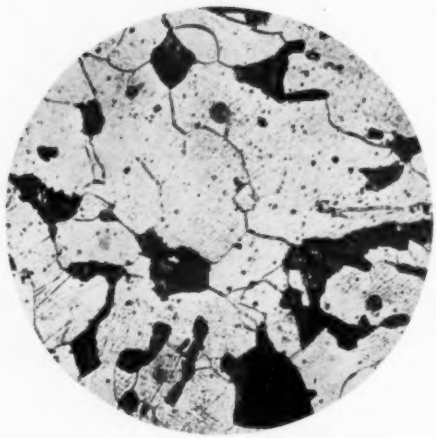

FIG. 20 OPEN HEARTH STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG. FAHR. STRUCTURE OF METAL AT CORE; 300 DIAMETERS

FIG. 21 OPEN HEARTH STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG. FAHR. DETAIL OF OUTER EDGE; 300 DIAMETERS

Note thin laminae of cementite which are most likely to cause spawl in service.

FIG. 22 OPEN HEARTH STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG. FAHR. VIEW AT POINT SLIGHTLY INSIDE THAT OF FIG. 21; 300 DIAMETERS

Fig. 23 Open Hearth Steel, 0.20% Carbon, Case Carbonized at 1300 Deg. Fahr. Nitrides at Inner Edge of Gradation Zone; 300 Diameters

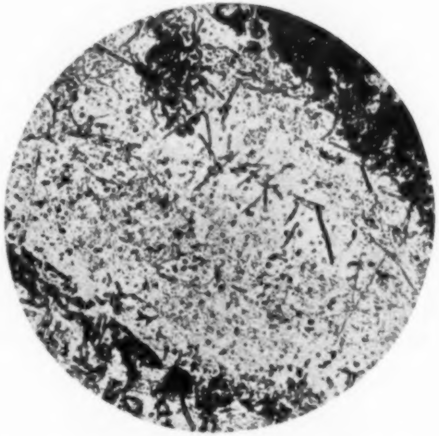

Fig. 24 Open Hearth Steel, 0.20% Carbon, Case Carbonized at 1300 Deg. Fahr. Nitrides in Ferrite Bands shown in Fig. 19; 300 Diameters

Nitrides are black lines seen in white ferrite bands; heavy black mass and black spots are pearlite, details of which could not be shown on account of over printing necessary to bring out nitrides.

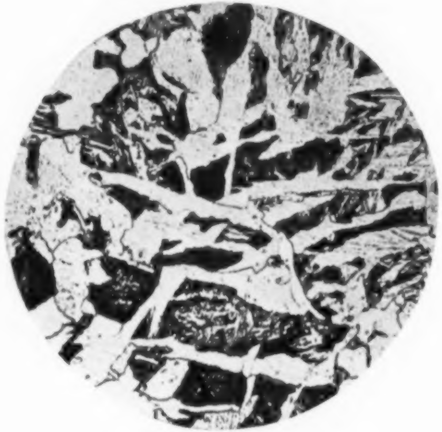

Fig. 25 Nickel Steel, 0.20% Carbon, Case Carbonized at 1700 Deg. Fahr. General Structure of Core; 300 Diameters

FIG. 26 NICKEL STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG FAHR. VIEW OF CEMENTITE NEEDLES TAKEN ABOUT IN MIDDLE OF ZONE OF EXCESS CEMENTITE; 300 DIAMETERS

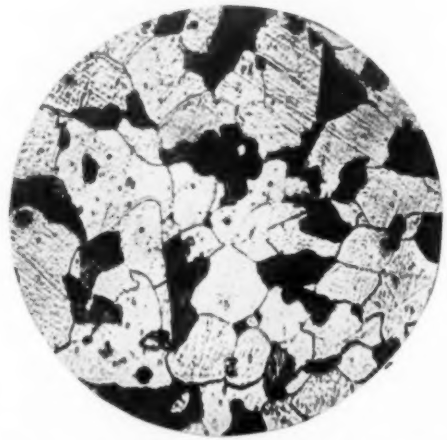

FIG. 27 CHROME VANADIUM STEEL, 0.20% CARBON, CASE CARBONIZED AT 1700 DEG. FAHR. STRUCTURE OF METAL IN CORE; 300 DIAMETERS

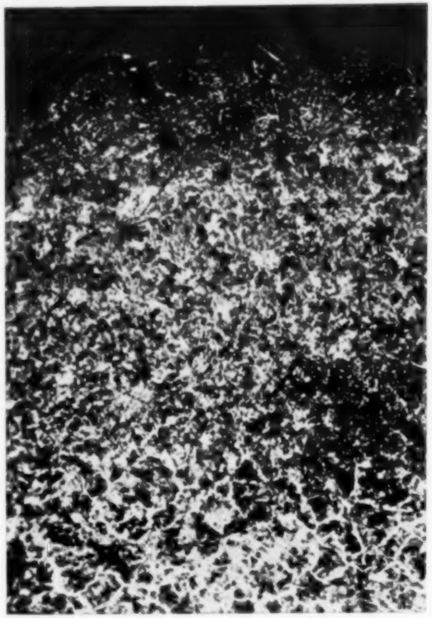

Fig. 28 Nickel Steel, 0.20% Carbon, Case Carbonized at 1700 Deg. Fahr. View shows Deeper Penetration of Carbon in Comparison with Fig. 18; 50 Diameters

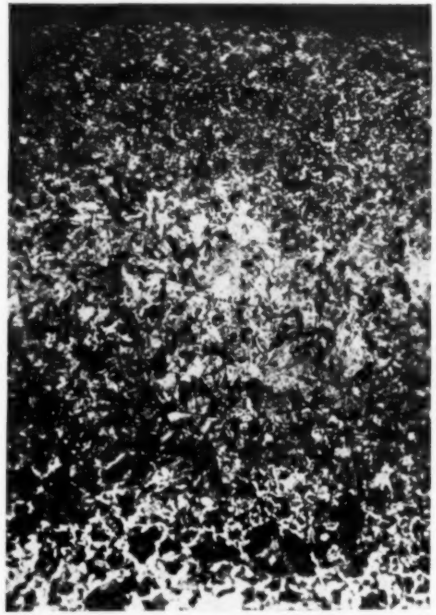

Fig. 29 Chrome Vanadium Steel, 0.20% Carbon, Case Carbonized at 1700 Deg. Fahr. Deep Penetration of Carbon and No Needles of Cementite in Outer Zone in Contrast to Figs. 18 and 28; 50 Diameters

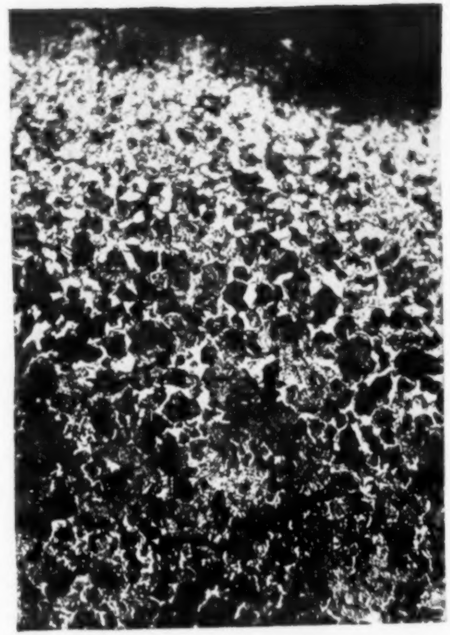

Fig. 30 Chrome Vanadium Steel, 0.20% Carbon, Case Carbonized at 1700 Deg. Fahr. View of Zone of Excess Cementite showing Tendency of Cementite to distribute Itself in Boundaries of Pearlite; 300 Diameters

MICROSCOPIC INVESTIGATION OF OPEN-HEARTH STEELS

TEST PIECE CASE CARBONIZED AT 1300 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 60 SECONDS

63 *Magnification 100 Diameters.* On the outside of this specimen is a zone of pearlite with excess cementite or ferrite in lines too fine for needle test about 0.0075 mm. thick. Inside this is a zone of beautiful lamellar pearlite, about 0.090 mm. thick, of eutectic composition. Further in there is a zone of gradation of carbon content about 0.03375 mm. thick, inside of which is the normal low carbon interior, the pearlite appearing in fine particles surrounded by ferrite. Total penetration of carbon is 0.1350 mm. Just inside the gradation zone and intermingled with it, there is scattered a large number of thin brown needles, varying in size from barely discernible specks to needles about 0.009 mm. long. Mr. K. W. Zimmerschied calls these needles nitrides, since he obtained similar ones by quenching some steel in ammonia. Penetrating the carbonized zone in many places around the circumference are bands of ferrite at various angles from 0 to 90 with the radius containing almost no pearlite, but a thick sprinkling of very minute specks and lines which may be nitrides.

64 *Magnification 400 Diameters.* Under this power the ferrite bands, containing nitrides, appear at intervals all the way around the circumference, more numerous in some parts than in others. These nitrides are more resolved at this power and hence more readily seen, but beyond this increased distinctness, the specimen appears as described above.

TEST PIECE CASE CARBONIZED AT 1400 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 45 SECONDS

65 *Magnification 100 Diameters.* In this specimen the depth of penetration of the carbon seems to be fairly uniform, averaging 0.420 mm. thick. On the outside there is a zone of irregular thickness, containing pearlite with fine lines of excess cementite. The average thickness of this zone is 0.060 mm. Inside the zone of excess cementite comes one of eutectic, about 0.150 mm. thick, followed by a gradation zone 0.225 mm. thick, in which the pearlite exists as large islands surrounded by fine lines of ferrite, growing more numerous toward the interior, until the normal core structure of small islands of pearlite surrounded by ferrite is obtained. The pearlite in the core has gathered into larger islands than in the specimen treated at 1300 deg. fahr. The nitride needles are present inside the eutectic zone, but are not so numerous as in the last specimen. The same is true of the bands of pure ferrite containing nitride needles which penetrate the carbonized zone.

66 *Magnification 400 Diameters.* At this magnification the pearlite throughout the entire carbonized zone is resolved into a beautifully lamellar structure. As before, we have an outer zone of pearlite with excess cementite, showing in places around the circumference small spots of pure cementite on the outer rim. The average thickness of this zone is 0.090 mm. The eutectic zone inside the zone of excess cementite is

approximately 0.120 mm. thick. The gradation zone is 0.1875 mm. thick, giving a total penetration of carbon of 0.3975 mm.

TEST PIECE CASE CARBONIZED AT 1500 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 30 SECONDS

67 *Magnification 100 Diameters.* Under this magnification the effect of carbonizing is noticed in a deeper zone of eutectic, but not in a much greater excess of cementite in the outer portions of the carbonized zone than was observed in the specimen treated at 1400 deg. fahr. On the extreme outer edge of the specimen we see a thin black rim about 0.023 mm. thick, of unresolvable material. Inside this rim we see progressively a zone of pearlite with excess cementite, showing slight crystalline outlines in places, about 0.1275 mm. thick. Next comes the eutectic zone, 0.240 mm. thick, giving a total penetration of carbon of 0.390 mm. This gradation zone varied from large islands of pearlite surrounded by lines of ferrite, to smaller islands of pearlite, surrounded by masses of ferrite. The pearlite on the interior seems to be in larger areas than in the last section surrounded by ferrite. No bands of ferrite, such as supposedly contained nitrides in the last specimens are visible here. Neither are any nitrides visible inside the eutectic zone.

68 *Magnification 400 Diameters.* At this magnification the pearlite in the carbonized zone is resolvable into a beautiful lamellar structure, while that in the core is mostly unresolvable in islands surrounded by ferrite, though some of it appears faintly lamellar. The outer zone of pearlite with excess cementite was 0.150 mm. thick. Inside this was a zone of eutectic 0.150 mm. thick, and then a gradation zone 0.420 mm. thick, giving a total carbon penetration of 0.720 mm. Along the inner part of the gradation zone, we come across a needle or two as we follow the zone around, which might be a nitride, but beyond these few solitary needles no traces, such as the bands cutting into the case, are visible.

TEST PIECE CASE CARBONIZED AT 1600 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 20 SECONDS

69 *Magnification 100 Diameters.* The carbonizing at this temperature appears to have increased the depth of the carbonized zone, but not to have formed a zone of much greater percentage excess cementite than was obtained at the last temperature. The thickness of the outer zone of pearlite and excess cementite varies around the circumference, but averages 0.0975 mm. Inside this zone we find a zone of eutectic averaging 0.345 mm. thick, and a zone of gradation averaging 0.300 mm., giving a total penetration of carbon of 0.7498 mm.

70 *Magnification 400 Diameters.* The pearlite is distinctly lamellar at this magnification, both in the carbonized zone, and in smaller laminations in the interior. The zone of excess cementite varies in thickness, but averages 0.135 mm. Inside this zone comes one of eutectic approximately 0.210 mm. thick, very irregular in depth, and then a gradation zone averaging 0.450 mm., giving a total penetration of carbon of 0.795 mm.

TEST PIECE CASE CARBONIZED AT 1700 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 20 SECONDS

71 *Magnification 100 Diameters.* In this specimen we get both a deeper penetration of carbon than in the last specimen, and a thicker zone of excess cementite. The zone of pearlite with excess cementite was very irregular in depth, but averaged 0.390 mm. In this zone we see a few long cementite needles within the pearlite of varying length and direction, but all of them in straight lines. Inside of this zone comes one of eutectic approximately 0.300 mm. thick, then a gradation zone of about 1.0725 mm., giving a total carbon penetration of 1.7625 mm.

72 *Magnification 400 Diameters.* At this magnification the pearlite appears in large laminations in the carbonized zone and in smaller laminations in the interior. The outer zone, containing pearlite with excess cementite, is approximately 0.225 mm. thick; inside of which comes the eutectic zone, approximately 0.338 mm. thick, and following this a gradation zone 0.60 mm. thick. The outer zone of pearlite with excess cementite contains a large number of cementite needles scattered through it. These needles are all straight lines but point in every direction, the largest of them being about 0.135 mm. long, the widest not over 0.00150 mm. wide. Both the excess cementite and the excess ferrite in their respective zones follow more or less the irregular crystal boundaries.

TEST PIECE CASE CARBONIZED AT 1800 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

73 *Magnification 100 Diameters.* In this specimen the excess cementite in the outer zone does not appear so much in the form of crystalline boundaries as it did in the preceding specimen, but more as irregular areas along the outer portion of the zone. The average thickness of this zone is about 0.1950 mm. Inside this zone comes the zone of eutectic, averaging approximately 0.585 mm., followed by a gradation zone averaging 0.975 mm., giving a total penetration of carbon of 1.755 mm. As before, the ferrite in the gradation zone appears in the form of outlines of crystals.

74 *Magnification 400 Diameters.* In this specimen the pearlite is beautifully lamellar in the carbonized zone and lamellar to a slight extent in the interior. On account of the great irregularity in the depth of penetration in the excess cementite in the outer zone, it is difficult at this magnification to obtain an average depth. The quantity of cementite needles within the pearlite grains has increased. The following figures are approximate: For the zone of excess cementite the depth is 0.293 mm. The depth of the eutectic zone is 0.450 mm. and that of the gradation zone 0.90 mm., giving a total penetration of carbon of 1.64 mm.

MICROSCOPIC INVESTIGATION OF CASE-CARBONIZED NICKEL STEELS

TEST PIECE CASE CARBONIZED AT 1300 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 40 SECONDS

75 *Magnification 100 Diameters.* At this magnification this specimen shows only a slight carbonization on the outside, apparently not even reaching the eutectic. In places around the circumference bands of darker material, looking like eutectic, extend quite a little distance into the section, very similar in appearance to the bands containing nitrides noticed in the open-hearth series. These bands occur only in two or three places. The interior of the section consists of finely divided pearlite with excess ferrite. Since the effect of carbonization is slight, it is difficult to tell where the carbonized zone ends and the normal interior structure begins, but an approximate figure of 0.045 mm. thickness gives a general idea of the depth of penetration of the carbon.

76 *Magnification 400 Diameters.* On the flat outer rim of this section appears to be a little pure ferrite, but this is a very thin rim, so that a needle test does not distinguish it from cementite. The pearlite in the carbonized zone is not resolvable at this power. The average depth of the carbonized zone is 0.180 mm. and no eutectic is present.

TEST PIECE CASE CARBONIZED AT 1400 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 40 SECONDS

77 *Magnification 100 Diameters.* The outer zone at this magnification appears to be of eutectic composition and an average thickness of 0.195 mm., inside of which comes a gradation zone approximately 0.390 mm. thick. The pearlite in the interior has gathered together slightly more than in the last specimen, and as before, is surrounded by ferrite. In this specimen we see ferrite bands at different places around the circumference penetrating the outer zone, which look almost the same as those found in the open-hearth series, especially in the specimen treated at this temperature, which contains nitrides.

78 *Magnification 400 Diameters.* The pearlite in the carbonized zone is faintly resolvable into the lamellar condition at this magnification. The highest carbon appears to be eutectic in a zone at the outside of the piece approximately 0.203 mm. thick. In one or two places there appear to be a slight excess of ferrite on the very outside, but this may be due to the rounding of the edges. The bands already mentioned, which penetrated the carbonized zone, are ferrite containing either nitrides or pearlite. At this power no needles which definitely resemble the nitrides are visible.

TEST PIECE CASE CARBONIZED AT 1500 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 20 SECONDS

79 *Magnification 100 Diameters.* In this specimen we get an irregular carbonized zone apparently not going beyond the eutectic in carbon content on the outside. The zone of eutectic, however, is much thicker than in the last specimen. The bands, which penetrated the carbonized zone

in the last specimen are here present in about the same number. The approximate thickness of the eutectic zone is 0.338 mm. The gradation zone is 0.585 mm., giving a total carbon penetration of 0.923 mm.

80 *Magnification 400 Diameters.* At this power we see an outer zone of eutectic approximately 0.278 mm. and a gradation zone of 0.510 mm. The total penetration of carbon is approximately 0.788 mm. The pearlite on the interior is just discernible as lamellar at this magnification and that in the carbonized zone is a little more easily recognized and also lamellar. The bands penetrating the eutectic on the outside appear to consist of pure ferrite with dark dots and smaller irregular lines scattered throughout.

TEST PIECE CASE CARBONIZED AT 1600 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

81 *Magnification 100 Diameters.* At this magnification there is little, if any, excess cementite in the outer zone of carbonization. There is, however, a thick zone of eutectic and inside this a zone of decreasing carbon. Also, in one or two places around the circumference we see the penetration bands which have been discussed in the last two or three specimens. The average thickness of the eutectic is 0.390 mm. That of the gradation zone is 0.683 mm. The total penetration of carbon is 1.073 mm.

82 *Magnification 400 Diameters.* At this magnification there appears to be a little excess cementite on the outer edge of the eutectic zone in places. This cementite appears in very fine lines like outlines of ferrite crystals. Since the cementite penetrates to varying depths and is present only in a small amount, we will consider the zone of eutectic as running out to the edge of the specimen and give for an average thickness of eutectic 0.338 mm., inside of which comes a gradation zone approximately 0.563 mm. The total penetration of carbon is 0.901 mm. The pearlite in the carbonized zone is resolvable in places into laminations. The maximum penetration of the excess cementite is about 0.180 mm.

TEST PIECE CASE CARBONIZED AT 1700 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

83 *Magnification 100 Diameters.* In this specimen the outer zone, containing pearlite with excess cementite, shows the needles of cementite scattered through it pretty freely, and as lines in the form of crystalline division. The whole outer zone, with the exception of the cementite needles and a few small white spots of cementite, appears to be pearlite. The thickness of this zone is 0.760 mm. Inside of this comes a gradation zone approximately 0.975 mm. The total penetration of carbon is 1.755 mm. No bands such as were seen in the last specimens and which penetrated the carbonized zone appear here, except in one spot where there is a slight penetration, the material looking like cementite.

84 *Magnification 400 Diameters.* At this power the zone of excess cementite containing needles of cementite is readily distinguished, and though varying in depth is approximately 0.473 mm. thick, inside of which

comes a zone of eutectic about 0.225 mm. thick. Inside of this is a gradation zone 0.675 mm. thick. The total penetration of carbon is 1.373 mm. The two bands of cementite already mentioned look like those described under the last specimen and may contain either this peculiar form of pearlite or nitrides.

TEST PIECE CASE CARBONIZED AT 1800 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

85 *Magnification 100 Diameters.* This specimen shows a greater penetration of the excess cementite than the last one, but the cementite appears in the form of irregular globules rather than as crystalline boundaries, in which form it appeared in the open-hearth series. The average depth of the zone of excess cementite is 0.293 mm. inside of which is the eutectic zone approximately 0.488 mm. thick, and inside of which a zone of decreasing carbon content approximately 1.28 mm. The total penetration of carbon is 2.061 mm. The bands penetrating the crystalline zone which appear in the last specimens are not present.

86 *Magnification 400 Diameters.* At this magnification the excess cementite in the outer zone is easily seen and appears principally as globules and finer lines, though only a few needles are present. The thickness of this zone is approximately 0.450 mm., inside of which comes a zone of eutectic approximately 0.428 mm. followed by a zone of decreasing carbon 0.15 mm., giving a total carbon penetration of 2.002 mm. The pearlite in the carbonized zone is only slightly resolvable at this magnification into lamellar pearlite. That on the interior is not resolvable at this power and may be troostitic.

MICROSCOPIC INVESTIGATION OF CHROME VANADIUM STEEL

TEST PIECE CASE CARBONIZED AT 1300 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 45 SECONDS

87 *Magnification 100 Diameters.* On the outside of this specimen is a black etching zone, unresolvable at this power, but probably eutectic pearlite, about 0.03 mm. thick, inside of which is a gradation zone 0.075 mm. thick. Inside these two zones is a black etching zone approximately 0.0675 mm. thick, which appears to be pearlite gathered together more or less in areas surrounded by lines of ferrite. The thicknesses of these individual zones varied but the carbon penetration was pretty and averaged 0.1725 mm.

88 *Magnification 400 Diameters.* On the outside there is a zone of pearlite containing small white globules that are probably cementite, though they are too small to apply the needle test, to distinguish them from ferrite. In places there is a very thin outer rim of cementite which confirms the above statement regarding the white globules. Inside this is a zone of very dark etching, faintly resolvable lamellar eutectic pearlite, approximately 0.03 mm. thick, inside of which is a gradation zone about 0.01575 mm. thick. This zone is difficult to measure since the carbon content grades off very slowly.

TEST PIECE CASE CARBONIZED AT 1400 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 30 SECONDS

89 *Magnification 100 Diameters.* On the outside there is a thick zone of eutectic showing possibly a slight excess cementite in fine lines on the outer edge in some places, the average thickness of the zone being about 0.15 mm. Inside of this zone is a gradation zone approximately 0.2475 mm. thick. As in the last specimen the decrease in carbon content is very gradual, making this zone difficult to measure. Total penetration of carbon is 0.03975 mm.

90 *Magnification 400 Diameters.* Here we see on the outside a thin rim about 0.0090 mm. thick of pearlite in excess cementite, inside of which comes a eutectic zone about 0.135 mm. thick, and then a gradation zone about 0.300 mm. thick, giving a carbon penetration of 0.444 mm.

TEST PIECE CASE CARBONIZED AT 1500 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 20 SECONDS

91 *Magnification 100 Diameters.* This specimen shows on the outside a definite zone of pearlite with excess cementite about 0.0525 mm. thick, inside of which is a eutectic zone about 0.4875 mm. and then a gradation zone of 0.195 mm. thick. Total penetration of carbon is 0.735 mm.

92 *Magnification 400 Diameters.* At this magnification there is a zone of pearlite with large excess cementite. This zone is about 0.06 mm. thick. inside it is a zone of pearlite, with just a little excess cementite, in small polygonal outlines, the average thickness of the zone being about 0.225 mm. thick, and then a eutectic zone about 0.180 mm. thick, followed by a gradation zone approximately 0.3375 mm. thick. The pearlite is not resolvable either in the carbonized zone or in the core. Total penetration of carbon is 0.8025 mm.

TEST PIECE CASE CARBONIZED AT 1600 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 150 SECONDS

93 *Magnification 100 Diameters.* Here we see a zone of pearlite with a large excess of cementite about 0.0375 mm., inside of which is a zone of eutectic about 0.51 mm. thick, and then a gradation zone 0.248 mm. thick. Total penetration of carbon is 0.795 mm.

94 *Magnification 400 Diameters.* With this magnification we see an outer zone about 0.045 mm. thick, consisting of cementite with pearlite in small areas throughout it. Then we come to a zone of pearlite containing excess cementite in fine polygonal outlines, this zone being about 0.1125 mm. Inside this zone is a eutectic zone approximately 0.2475 mm. thick, followed by a gradation zone approximately 0.2775 mm. thick, giving a total penetration of carbon of about 0.6825 mm. The pearlite in the carbonized zone is mostly unresolvable, though some of it shows very fine laminations. That on the interior is resolvable into fine lamellar pearlite.

TEST PIECE CASE CARBONIZED AT 1700 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

95 *Magnification 100 Diameters.* On the outside of this specimen we see a sharply defined zone of pearlite with excess cementite approximately

0.067 mm. thick. Next comes a zone of eutectic about 0.8755 mm. thick, followed by a gradation zone about 0.4875 mm. thick. Total penetration of carbon is 1.430 mm.

96 *Magnification 400 Diameters.* Here, as in the last specimen, we get a sharply defined zone of cementite with small areas of pearlite scattered through it, apparently a little more pearlite than half and half, this zone being about 0.105 mm. thick. Inside this is a zone about 0.360 mm. thick, which contains pearlite surrounded by thin lines of cementite in polygonal outlines. Then comes the eutectic zone about 0.405 mm. thick, followed by a zone of gradation approximately 0.45 mm. thick. The carbon content in the latter changes very slowly so that the zone is difficult to measure. Total penetration of carbon is 1.320 mm.

TEST PIECE CASE CARBONIZED AT 1800 DEG. FAHR., ETCHED IN 5 PER CENT PICRIC ACID FOR 15 SECONDS

97 *Magnification 100 Diameters.* This specimen shows a zone on the ourside of pearlite surrounded by fine lines of cementite, this zone being about 0.15 mm. thick. There comes a zone of eutectic approximately 0.975 mm. thick, followed by a gradation zone approximately 0.795 mm. thick, giving a total carbon penetration of 1.92 mm. In various places throughout the carbonized zone appear irregularly shaped areas not over 0.675 mm. approximately, or their longest dimension, which are unresolvable at this power.

98 *Magnification 400 Diameters.* At this magnification, we see a wide zone, about 0.3375 mm. thick, containing pearlite with excess cementite in fine lines showing polygonal figures, like boundaries between ferrite crystals. Inside this comes a zone of eutectic 0.5625 thick, followed by a gradation zone 0.675 mm. thick, giving a total penetration of carbon of 1.575 mm. The white spots above noticed were shown to be cementite by scratching with a needle. In some places there are little white spots containing fine brown lines possibly looking like lamellar pearlite, in which the ferrite layer is very thin, much thinner than the cementite, in some cases only one-seventh to one-tenth as wide. This structure has been noticed in nearly all the areas containing excess cementite.

APPENDIX NO. 3

EFFICIENCY OF CASE-CARBONIZING MATERIALS

CASE-CARBONIZING MATERIAL NO. 1

Etched in 2.5 Per Cent Picric Acid for 45 Minutes

99 *Run No. 1, Bar No. 1.* On the outside of this specimen is a uniform zone 0.455 mm. thick of pearlite containing lines of excess cementite; inside is a zone of eutectic pearlite 0.455 mm. thick, followed by a gradation zone 0.650 mm. thick, inside of which comes the normal structure of about 0.20 per cent carbon steel consisting of ferrite containing small islands of pearlite. The pearlite throughout the section is lamellar. Total penetration of carbon is 1.560 mm.

100 *Run No. 2, Bar No. 7.* This specimen shows the outer zone of eutectic pearlite 0.715 mm. thick, inside of which comes a gradation zone 1.001 mm. thick, followed by the normal interior of ferrite containing islands of pearlite. The pearlite throughout the section is lamellar. Total penetration of carbon is 1.716 mm.

Etched in 2.5 Per Cent Picric Acid for 30 Seconds

101 *Run No. 3, Bar No. 13.* This specimen shows an outer zone of eutectic 0.358 mm. thick, inside of which is a gradation zone 1.138 mm. thick, surrounding the normal low carbon interior structure. Total penetration of carbon is 1.496 mm.

Etched in 2.5 Per Cent Picric Acid for 60 Seconds

102 *Run No. 1, Bar No. 2.* This specimen shows an outer zone of lamellar pearlite containing lines of excess cementite, the zone being 0.450 mm. thick. Inside this zone comes a zone of eutectic 0.650 mm. thick, followed by a gradation zone 0.748 mm. thick, giving a total penetration of carbon of 1.848 mm. Inside these zones is the normal low carbon structure.

103 *Run No. 2, Bar No. 8.* On the outside of this specimen is a zone of eutectic 0.650 mm. thick, inside of which comes a gradation zone 1.073 mm. giving a total penetration of carbon of 1.723 mm. The outer zone contains numerous small white areas, probably of ferrite, but too small to scratch with a needle.

Etched in 2.5 Per Cent Picric Acid for 70 Seconds

104 *Run No. 3, Bar No. 14.* In this specimen the ferrite penetrates to the very edge in many places around the circumference and the effect of the carbonizing has been simply to raise the carbon content of the outer portion, forming a zone of decreasing carbon about 0.975 mm. thick.

CASE-CARBONIZING MATERIAL NO. 3

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 45 SECONDS

105 *Run No. 1, Bar No. 3.* Outer zone of eutectic is 0.520 mm. thick; inside this is a zone of gradation 1.235 mm. thick, giving a total penetration of carbon of 1.755 mm. The outer zone contains small white spots looking like ferrite, but too small to scratch.

106 *Run No. 2, Bar No. 9.* On the outside a rather irregular zone of eutectic approximately 0.520 mm. thick, inside of which is a gradation zone 1.300 mm. giving a total penetration of carbon of 1.820 mm. thick. The outer zone of eutectic contains here and there small islands probably of ferrite, too small to scratch with the needle.

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 60 SECONDS

107 *Run No. 3, Bar No. 15.* Outer zone of eutectic in places, but penetrated quite often along the circumference by ferrite bands so that it is questionable whether even the very outside has reached the carbon content of the eutectic. From the outside the carbon content decreases to that of the normal low carbon interior, this gradation zone being 0.325 mm. thick, which is the total penetration of carbon.

CASE-CARBONIZING MATERIAL NO. 1

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 60 SECONDS

108 *Run No. 1, Bar No. 4.* On the outside of this specimen is a zone of eutectic 0.975 mm. thick, inside of which is a gradation zone 1.300 mm. thick, giving a total penetration of carbon of 2.275 mm. In places along the outer zone there are small islands of white material, either cementite or ferrite too small to scratch with the needle and containing very fine lines of pearlite in lamellation.

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 50 SECONDS

109 *Run No. 2, Bar No. 10.* On the outside is a zone of eutectic approximately 0.878 mm. thick, inside of which comes a zone of gradation 0.975 mm. thick, giving a total penetration of 1.853 mm. As in the other specimens there are small spots of white material scattered through the outer zone.

110 *Run No. 3, Bar No. 16.* On the outside is a zone of eutectic approximately 0.455 mm. thick, quite irregular and in places having ferrite penetrating it to the edge of the specimen. Inside of this zone comes one of decreasing carbon 0.975 mm. thick, giving a total penetration of carbon of 1.43 mm.

CASE-CARBONIZING MATERIAL NO. 5

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 60 SECONDS

111 *Run No. 1, Bar No. 5.* On the outside of this specimen is a zone of lamellar pearlite containing lines of excess cementite in polygonal outline as usual, this zone being about 0.780 mm. thick; inside comes the eutectric zone 0.520 mm. thick, followed by a zone of gradation 0.975 mm. thick, giving a total penetration of carbon of 2.275 mm.

112 *Run No. 2, Bar No. 11.* On the outside is a eutectic zone approximately 0.780 mm. thick but quite irregular in depth. Then comes a gradation zone 0.975 mm. thick, giving a total penetration of carbon of 1.755 mm. As usual in the outside zone are small white spots of ferrite or cementite too small to scratch with the needle.

113 *Run No. 3 Bar No. 17.* In this specimen is an outer zone of eutectic 0.225 mm. thick, containing several white spots of ferrite, inside of which comes a gradation zone of 1.300 mm. thick, giving a total penetration of carbon of 1.525 mm.

CASE-CARBONIZING MATERIAL NO. 6

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

114 *Run No. 1, Bar No. 6.* This carbonizing compound did not even bring the outer skin of the metal up to eutectic but carbonized the outside slightly to a depth of 1.235 mm., which is the total penetration of carbon.

Etched in 2.5 Per Cent Picric Acid for 60 Seconds

115 *Run No. 2, Bar No. 12.* This specimen shows an outer zone of increased carbon content not as high as eutectic, the zone being 0.975 mm. thick, which is the total penetration of carbon.

116 *Run No. 3, Bar No. 18.* On the outside of this specimen is a zone of increased carbon content not as high as eutectic, 0.040 mm. thick.

CASE-CARBONIZING MATERIAL NO. 7

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

117 *Run No. 1, Bar No. 19.* On the outside of this specimen is a zone of lamellar pearlite containing lines of excess cementite more or less in polygons, the depth of the zone being 0.325 mm. thick, inside this comes a eutectic zone 0.520 mm. thick, and inside this a gradation zone 0.975 mm. thick, giving a total penetration of carbon of 1.920 mm.

Etched in 2.5 Per Cent Picric Acid for 50 Seconds

118 *Run No. 2, Bar No. 25.* On the outside is a zone of eutectic approximately 2.60 mm. thick, containing small spots of white material probably ferrite in one or two places; inside comes a gradation zone 1.300 mm. thick, giving a total penetration of carbon of 1.560 mm.

Etched in 2.5 Per Cent Picric Acid for 60 Seconds

119 *Run No. 3, Bar No. 31.* On the outside is a zone of eutectic approximately 0.715 mm. thick, containing a little excess ferrite in spots around it, in some places the ferrite extending almost to the edge. Inside of this comes a gradation zone 1.170 mm. thick, giving a total penetration of carbon of 1.995 mm.

CASE-CARBONIZING MATERIAL NO. 8

Etched in 2.5 Per Cent Picric Acid for 50 Seconds

120 *Run No. 1, Bar No. 20.* This specimen shows an outer zone of lamellar pearlite containing polygonal lines of excess cementite, the zone

being approximately 0.455 mm. thick; inside comes a eutectic zone 0.520 mm. thick and a gradation zone 0.975 mm. thick, giving a total penetration of carbon of 1.950 mm.

121 *Run No. 2, Bar No. 26.* On the outside is a zone of lamellar pearlite containing fine lines of excess cementite following the boundaries of the ferrite crystals as usual, the thickness of the zone averaging 0.325 mm.; inside is a zone of eutectic 0.715 mm. thick, followed by a gradation zone 0.910 mm. thick, giving a total penetration of carbon of 1.950 mm.

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

122 *Run No. 3, Bar No. 32.* On the outside is a zone of lamellar pearlite containing a little excess cementite in very fine lines following the boundaries of the ferrite crystals. The thickness of this zone is 0.195 mm. Inside of this comes a eutectic zone 0.650 mm. thick, followed by a gradation zone 0.650 mm. thick, giving a total penetration of carbon of 1.495 mm.

CASE-CARBONIZING MATERIAL NO. 9

Etched in 2.5 Per Cent Picric Acid for 45 Seconds

123 *Run No. 1, Bar No. 21.* On the outside of this specimen is a zone 1.235 mm. thick of lamellar pearlite containing lines of excess cementite in rather thick lines around the ferrite crystals and showing small cementite needles in places, which appear to branch off from the main crystaline boundaries. Inside comes a eutectic zone 0.423 mm. thick, followed by a gradation zone 0.780 mm. thick, giving a total penetration of carbon of 2.438 mm.

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

124 *Run No. 2, Bar No. 27.* On the outside is a zone 1.075 mm. thick of lamellar pearlite containing lots of excess cementite in polygonal outlines, but no cementite needles such as were noticed in the last specimen. Inside this comes a eutectic zone 0.455 mm. thick, followed by a gradation zone 0.780 mm. thick, giving a total penetration of carbon of 2.300 mm.

Etched in 2.5 Per Cent Picric Acid for 50 Seconds

125 *Run No. 3, Bar No. 33.* On the outside is a zone of lamellar pearlite containing lines of excess cementite outlining the ferrite crystals as usual, the depth of the zone being 0.325 mm. Inside this comes a zone of eutectic 0.845 mm., followed by a gradation zone 0.975 mm. thick, giving a total penetration of carbon of 2.145 mm.

CASE-CARBONIZING MATERIAL NO. 10

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

126 *Run No. 1, Bar No. 22.* On the outside of this specimen is a zone of eutectic approximately 0.975 mm. thick, containing spots here and there of white material probably ferrite, such as were noticed in the other specimens. Inside comes a gradation zone 1.105 mm. thick, giving a total penetration of carbon of 2.080 mm.

Etched in 2.5 Per Cent Picric Acid for 50 Seconds

127 *Run No. 2, Bar No. 28.* On the outside is a eutectic zone rather irregular in depth but averaging 0.065 mm., so that the ferrite penetrates to the circumference in some places. Inside comes one of decreasing carbon 1,170 mm. thick, giving a total penetration of carbon of 1.235 mm.

Etched in 2.5 Per Cent Picric Acid for 15 Seconds

128 *Run No. 3, Bar No. 34.* On the outside is a rim of pure ferrite 0.065 mm., inside of which is a carbonized zone in which the carbon content decreases to that of the interior. This zone is 0.910 mm. thick, giving a total penetration of carbon of 0.975.

CASE-CARBONIZING MATERIAL NO. 11

Etched in 2.5 Per Cent Picric Acid for 55 Seconds

129 *Run No. 1, Bar No. 23.* On the outside of this specimen is a zone of eutectic varying in depth, in some places almost reaching the edge, but of an average depth of 0.195 mm. Inside of this comes a gradation zone 1.300 mm. thick, giving a total penetration of carbon of 1.495 mm.

130 *Run No. 2, Bar No. 29.* This specimen was not carbonized up to the eutectic even on the outside, so that there is simply a zone of decreasing carbon content approximately 1.658 mm., which is the total penetration of carbon.

Etched in 2.5 Per Cent Picric Acid for 50 Seconds

131 *Run No. 3, Bar No. 35.* On the outside is a thin rim, maximum thickness 0.007 mm., of ferrite not continuous, but present on most of the circumference. Inside comes a zone of gradation 1.235 mm. thick, giving a total penetration of carbon of 1.242 mm.

CASE-CARBONIZING MATERIAL NO. 12

Etched in 2.5 Per Cent Picric Acid for 60 Seconds

132 *Run No. 1, Bar No. 24.* On the outside of this specimen is a rather irregular zone 0.329 mm. thick, of eutectic containing white specks here and there as noted in the other specimens. Inside comes one of gradation 1.235 mm. thick, giving a total penetration of carbon of 1.574 mm.

Etched in 2.5 Per Cent Picric Acid for 65 Seconds

133 *Run No. 2, Bar No. 30.* On the outside of this specimen we see a zone of eutectic very irregular and penetrated now and again by ferrite bands. The average thickness of this zone is 0.130 mm. Inside of this comes a gradation zone 1.560 mm. thick, giving a total penetration of carbon of 1.690 mm.

134 *Run No. 3, Bar No. 36.* On the outside is a rim of pure ferrite in some places, in others this is not present. The maximum thickness is 0.007 mm., and inside this comes a gradation zone 1.560 mm. thick, totaling 1.567 mm.

CASE-CARBONIZING MATERIAL NO. 13

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 55 SECONDS

135 *Run No. 1, Bar No. 37.* On the outside of this specimen is a zone of lamellar pearlite containing excess cementite in thin polygonal outlines. The depth of penetration of these outlines varies, but averages 0.325 mm. Inside comes a zone of eutectic 0.520 mm. thick, followed by a gradation zone 1.300 mm., giving a total penetration of carbon of 2.145 mm.

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 70 SECONDS

136 *Run No. 2, Bar No. 39.* On the outside is a zone of eutectic approximately 0.520 mm. thick, but very irregular, in some cases the ferrite globules penetrate almost to the edge. Inside comes a gradation zone of 1.170 mm., giving a total penetration of carbon of 1.690 mm.

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 80 SECONDS

137 *Run No. 3, Bar No. 41.* On the outside is a zone of eutectic averaging 0.291 mm., but very irregular and containing spots of ferrite here and there, penetrated more or less by the ferrite bands from the interior. Inside comes a gradation zone of 1.170 mm. thick, giving a total penetration of carbon of 1.463 mm.

CASE-CARBONIZING MATERIAL NO. 14

ETCHED IN 2.5 PER CENT PICRIC ACID FOR 55 SECONDS

138 *Run No. 1, Bar No. 38.* On the outside of this specimen is a zone of lamellar pearlite containing a great deal of excess cementite, both as polygonal outlines and in a few places as long thick cementite needles. The depth of penetration of this excess cementite varies, but averages 1.040 mm. Inside comes a eutectic zone 0.339 mm. thick, followed by a gradation zone 0.650 mm. thick, giving a total penetration of carbon of 2.029 mm.

139 *Run No. 2, Bar No. 40.* On the outside is an irregular zone of lamellar pearlite containing excess cementite, both as polygonal outlines and large needles, and averaging 1.300 mm. thick. Inside comes a zone of eutectic 0.450 mm. thick, followed by a gradation zone 1.105 mm., giving a total penetration of carbon of 2.855 mm.

140 *Run No. 3, Bar No. 42.* Outer zone of lamellar pearlite containing excess cementite averaging 1.170 mm, both as polygonal outlines and as needles. Inside comes a zone of eutectic of 0.845 mm. thick, followed by a gradation zone of 1.300 mm. giving a total penetration of carbon of 3.315 mm.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

It is the purpose to cover in the Foreign Review as wide a range of subjects as space permits, endeavoring at the same time to present the salient points of the articles abstracted and the most valuable engineering data contained in them. The usefulness of the Review will be further increased through arrangements lately made by the library of the Engineering Societies, including that of The American Society of Mechanical Engineers, to add to the number of publications in the Slavonic languages received at the library. For the mechanical engineer this is of importance owing to the wide application of the oil engine in Russia which is in this respect in a position very similar to that of the United States.

THIS MONTH'S ARTICLES

Among this month's articles will be found one on the thermodynamics of the gas turbine by Dejmek abstracted from the journal of the Bohemian Society of Engineers and Architects and one by the designer of the first large gas turbine in actual operation, engineer Holzwarth. With respect to reciprocating internal combustion engines attention is called to the description of the Sabathé engine and the accompanying discussion of the mixed combustion process, as well as to the article by Mérigeault on the influence of the speed of combustion on the efficiency of a gas engine. Mader's article on the micro-indicator describes an apparatus intended to be used with high speed small internal combustion engines where an ordinary indicator does not give satisfactory results.

The experiments of Christlein reported in The Journal for February 1912, by showing how comparatively inexact has been our knowledge of the processes of flow of elastic fluids through nozzles, have attracted a good deal of attention to this subject. An article investigating the relation between the velocity of flow and the so-called acoustic velocity by Zerkowitz is to be found

in abstract in this month's Review. K. Schultze describes a method for determining the steam consumption of a turbine plant without the use of expensive steam meters or the application of methods of measurement beyond the ability of the usual plant attendants. Attention is also called to the article on the application of compressed air in the atomization of liquid fuel in locomotives, mainly because the author claims to have obtained an unusual economy of 38 per cent where American engineers have practically found no improvement at all.

A series of articles on the Cardan drive, ball bearings, lubrication tests, etc. will be found in the section on Mechanics, while in the section of Air Machinery are described several interesting types of air conditioning apparatus of German design. Of articles on autogenous welding one gives results of an investigation of constructional requirement of an oxy-acetylene welding burner and the other data of an important investigation on the strength of welded seams by Desjuzeur, director of the Lyons association of Owners of Steam Machinery, whose investigation on boiler sheets has been reported in the preceding number.

A new process for the manufacture of iron and steel is also reported, and attention is called in this connection to the numerous attempts of applying coal dust as fuel in internal combustion engines made in England lately. Data on the efficiency of sand blasting machines are also given. In conclusion may be mentioned the report of the work of Imbert on measuring the labor output of a workman, and graphically showing the relative efficiency of a skilled workman and an apprentice.

The Editor will be pleased to receive inquiries for further information in connection with articles reported in this Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Aeronautics

STARTING COURSE (*Anlaufweg*, G. König, *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 3, no. 19, p. 247. October 12, 1912. 1 p., 1 fig. *t*). A mathematical demonstration that the length of the start run is proportional directly to specific load on the planes and normal velocity of flow, and inversely to the specific efficiency (referred to unit weight of the flying machine) in the equation for length of start, there being also

a factor to take care of the constructional pecularities of each type. The length of the start run increases in squares when the net weight of the airship is increased by some useful load (in the first degree).

APPARATUS FOR MEASURING STRESSES IN THE STAYWIRES OF AIRSHIPS (*Apparat zur Messung der in den Drahten eines Flugapparates auftretenden Spannungen*, Wittmaack. *Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 3, no. 19, p. 250. October 12, 1912, 2 pp., 2 figs. *d*). Description of the Largier apparatus described in The Journal, May 1912, p. 806. The author of the present article states that the apparatus has not yet been tried for measuring stresses during actual flight.

Air Machinery and Ventilation

UNDERGROUND TRACTION BY COMPRESSED AIR LOCOMOTIVES IN FRENCH MINES (*La traction souterraine par locomotives à air comprimé dans les mines françaises*, E. Leroux. *Bulletin de la Société de l'Industrie Minérale*, September 1912. p. 299. 36 pp., 22 figs. *de*). Description of some compressed air mine locomotives and data of tests, among others those of the Leroux locomotive.

PNEUMATIC POST IN ITALY (*La posta pneumatica in Italia. L'Industria*, vol. 26, no. 39, p. 613. September 29, 1912. 7 pp., 26 figs. *d*). Description of the pneumatic post installation in Milan, Italy. German apparatus of the closed-circuit type is used, the parcels in the tubes moving at a speed from 500 m (1640 ft. contract speed) to 700 m (2296 ft. speed at tests). Each parcel may contain from 15 to 20 letters and telegrams.

PRESSURE PIPING OF AN UNDERGROUND MINE PUMPING ENGINE (*Druckleitung einer unterirdischen Wasserhaltungsmaschine*, Ed. Kaschny. *Der praktische Maschinen-Konstrukeur*, vol. 45, no. 21, p. 350. October 10, 1912. 2 pp., 3 figs. and one sheet of drawings. *d*). *Wrought-iron or seamless steel tubes* have the following advantages as compared with *cast-iron ones*: greater length and therefore fewer flange connections per unit of length; thinner walls, and therefore easier handling, lower stress of the foundations and lower expenses of installation. If cast-iron pipes are still used, however, this may be partly explained by the usual unwillingness of mine owners to try new things, and partly by the idea that cast iron is better able to resist corrosion due to the action of mine waters; as to the latter it has been found, however, that a properly applied coat of tar affords a practically perfect protection to wrought-iron and steel pipes. The rest of the article contains a detailed description of the piping in a Russian mine the name of which is not given.

NEW VENTILATING APPARATUS IN 1911 (*Neuerungen in der Lüftungstechnik aus dem Jahre 1911. Zeits. für Beleuchtungswesen*, vol. 18, no. 28, p. 327. October 10, 1912. 2 pp., 6 figs. *d*). Descriptions of new types of *air conditioning apparatus* of German design. The author states that it was in the United States that the tendency to build apparatus which would simultaneously wash the air and condition it originated. The device shown in Fig. 1A, was patented in Germany (patent No. 239583) by H. Assmuth, a resident of Daressalam, German East Africa, and is primarily designed for use in *tropical countries*. It combines an air

cooling apparatus with an air distributor, the cooling being based on the variation of the temperature of the air with changes in its pressure. *P* is an air pump surrounded by the jacket *W*; *B* is a tank containing the suc-

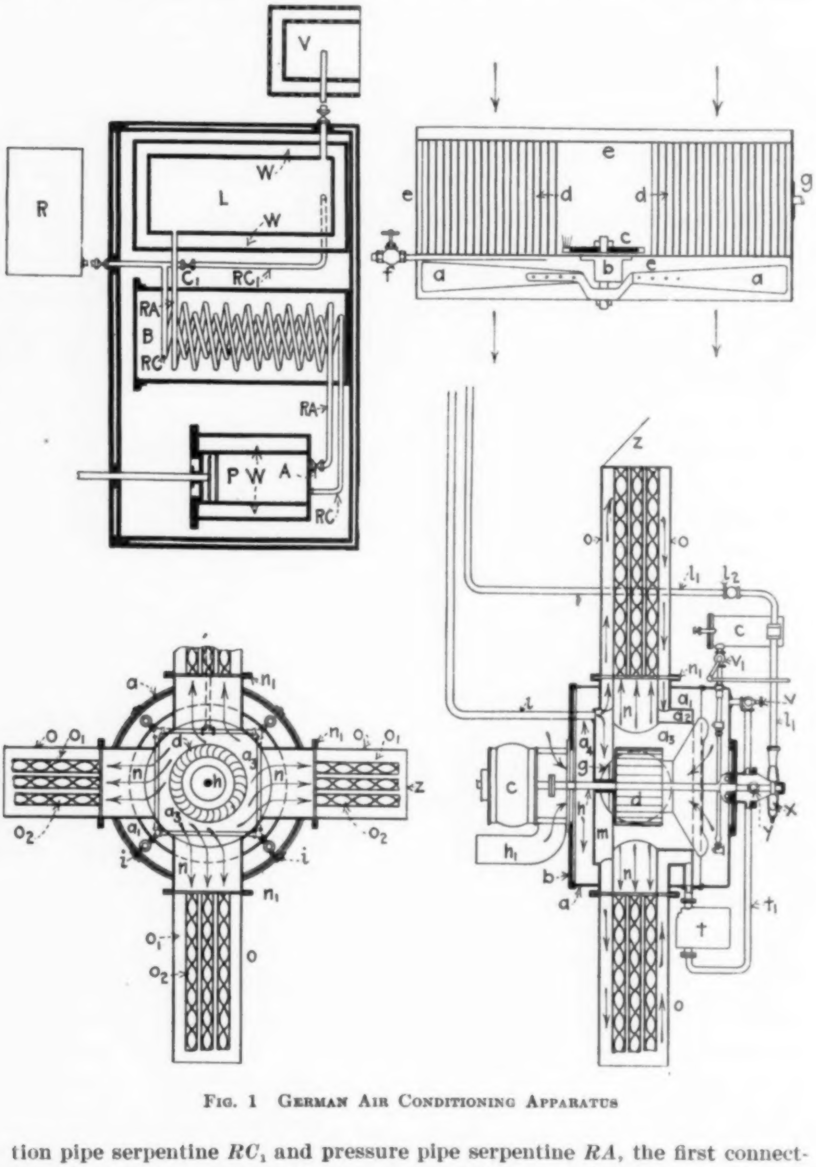

FIG. 1 GERMAN AIR CONDITIONING APPARATUS

tion pipe serpentine RC_1 and pressure pipe serpentine *RA*, the first connecting with the air reservoir *L*, also surrounded by a jacket *W*; *V* is the distributor, and *R* air cleaner. The jackets *W* are filled with water, the tank *B*

with a heat exchanging medium (ice, steam, etc.), while all the piping and valves are carefully protected against heat losses. If the valves C and C_2 are closed, only the air cooling part is in operation, while the air cleaner is cut out. At the suction stroke of the pump P, with admission valve C_1 open, the air flows through the suction serpentine RC_1 from the reservoir L and is partly cooled in passing through the tank B, while at the same time it takes heat away from the water around L. At the compression stroke of the pump P the exhaust valve A opens, and admission valve C_1 closes, the air is driven through the pressure serpentine RA, gives up heat to the water in the jacket around the pump, and is cooled first by the ice in the tank B, and next by expanding in L. The distributor V consists of two fine meshed wire nets insuring slow and uniform flow of air into the room, this being necessary because strong and non-uniform air currents, particularly of cold' air, have an evil influence on the health.

A similar apparatus patented in Germany (patent No. 243341) by Konrad Marquards is *for use in textile plants.* The chamber a has three concentric cavities, the innermost one containing a fan d (Fig. 1B and C). The casing e encloses four water atomizing nozzles i, and supports by its bottom the centrifugal pump x which is on a common vertical shaft with the fan d, and is driven by the electromotor c. The outer circular cavity a_1 serves for the atomization of the water, while the cavity a_2 which forms, by means of a double roof, a second cavity m, serves as a steam space. Through the cavities a_1 and a_2 pass four pipes n starting from the ventilator chamber a_3 and joined at the other end to the four air distributing and heating pipes o. Sections of the pipes n form the connecting ducts q and q_1, the first between the pipes o and steam space m, and the other between these pipes and the steam space a_2. The steam passes through the steam supply pipe r (Fig. 1C) and connecting pipe q, as shown by the dotted lines, into the steam space m, and thence into the air heating pipes o, where it flows around the heating pipes o_1, finally to reach the steam space a_2. The water of condensation moves in the same direction and flows into the water pot t from which it passes through pipe t_1 to the centrifugal pump x and thence either to the atomizing nozzles or to the sewage piping r_1, the water serving for air moistening passing preliminarily through the sieves at s_1. If the air has only to be heated, but no water is to be atomized, the valves v and v_1 are closed, and all the water sent through pipe r. If, on the contrary, it is desired only to moisten the air, but not heat it, the regulating valve r_2 is closed completely. The path of the air in all cases is indicated by the arrows. Outside air is sucked in by the fan d, and passes consecutively through the circular chambers a_4, a_1 and a_3, becoming somewhat warmed up by the contact with the external walls of the chamber a_2. It flows then through the connecting pipes n and heating pipes o_1 into the workshops, so that in winter ventilation and heating occur simultaneously. In ventilation without heating (e.g. in summer) the air is taken in by the fan through the pipe k_1 and let out into the workrooms through pipes o and o_1. The moistening of the air occurs in the chamber a_1

where the air and the water jets from the atomizing nozzles come together.

H. R. Gabler in his patent (No. 243610) combines an ***exhaust steam turbine fan drive with heating by the same exhaust steam,*** both being done in a single unit. As shown in Fig. 1D, *a* is the fan wheel, *b* the bearing, *c* turbine wheel, *d* air pipes built into the heater, *e* heater, *f* steam supply piping, *g* water of condensation discharge piping. Steam coming through pipe *f* sets into motion the turbine wheel *c* and the fan wheel *a* directly coupled with the latter; while the air driven by suction through the pipes *d* is heated, and at the same time condenses the exhaust steam.

The article contains also a description of the air conditioning apparatus of A. Sauer, of Pittsburgh. It is to be continued.

MINE FAN DRIVE BY POLYPHASE MOTORS WITH VARIABLE SPEEDS OF ROTATION (*Antrieb von Grubenventilatoren durch Drehstrommotoren mit regelbarer Umlaufzahl,* Sauvage. *Glückauf,* vol. 48, no. 41, p. 1668. October 12, 1912. 3 pp., 4 figs. *cp*). At the Hermine mine in Neunkirchen (Trier, Germany) was installed a fan plant designed to supply at the time of its installation 5600 cbm (say 200,000 cu. ft.) of air per min., but to be able to supply later 8000 cbm (say 282,000 cu. ft.) per min. A Rateau fan of the latter maximum capacity was installed, with a speed varying in accordance with the output desired between 150 and 220 r.p.m. Three-phase current was available at 2000 volts and a frequency of 50. The article describes in detail the somewhat unusual electric equipment of the plant and its testing. During the tests three methods of regulation were applied: by a regulating starter, by varying resistances with asynchronous motors, and by throttling the suction piping of the fan. Fig 2A gives a comparison of the first two methods, showing, by the way, that at low speeds and correspondingly low fan outputs change from Delta connection to Star connection improves the efficiency. Fig. 2B shows the power consumption at various outputs with all three methods of regulation, proving, as might be expected, that for all but the very highest outputs, regulation by throttling is the least economical.

In the present case the first cost of the regulating apparatus increased the cost of the motors by M.15000 (roughly, $3700). If the installation were driven during the first 16 months at an average speed of 340 r.p.m., or at 70 per cent of maximum air output, there would be a saving of 53 kw. during that time, or, at 8500 hours per year and at 2.5 pf. (say $0.006) per kw-hr., there would be in those first 16 months a saving of $16\times8500\times53\times2.5 \div 12\times100=$ M 15,016.66, or the extra first cost would be saved in less than a year and a half.

A NEW BLOWER (*Ein neues Gebläse,* J. Lehne. *Die Turbine,* vol. 9, no. 1, p. 11. October 5, 1912. 2 pp., 2 figs. *d*). After discussing the usual disadvantages of blowers using an auxiliary liquid the author describes a new blower of the International Rotary Machine Company of Berlin using a constantly rotating ring of liquid *c* enclosed, to avoid excessive friction losses, in a freely revolving drum *b* (Fig. 3B), whereby the small friction at the bearings is substituted for the considerable frictional resistances at high velocities. Eccentrically to the axis of this

drum is placed a blade disc *a* enclosed by side plates as shown, touching the ring of liquid at one place of its inner circumference while everywhere else there is a certain distance between the edges of the blades and the circumference of the ring varying from zero to maximum and back to zero. As the drum is very rotatably placed in the ball bearings *d* and *e* (Fig. 3A), it is easily carried away in its rotation by the ring of liquid, which thus forms an air-tight enclosure of the separate cell spaces. Inside the wheel *a* is a fixed wrist plate *f* with a suction duct *g* and pressure duct *h*, the latter so proportioned that it is set in connection with the corresponding cell-openings only after the pressure in the respective cells has reached exactly that level for which the apparatus is designed.

Tests with small machines having a wheel with inner diameter of

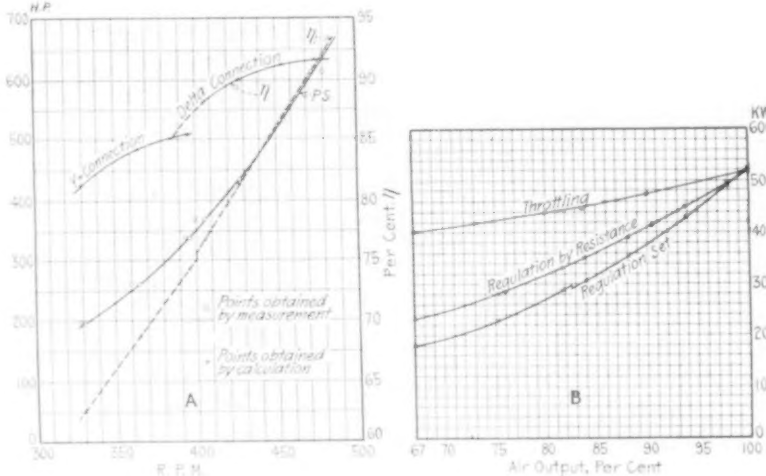

FIG. 2 MINE FAN DRIVE BY POLYPHASE MOTORS, EFFICIENCY AND ECONOMY OF REGULATION

80 mm (3.14 in.) have shown an efficiency of 60 to 73 per cent when the machine worked as a blower, and 50 to 63 per cent when as a vacuum pump. Pressures up to 1.2 atmospheres above atmospheric have been obtained with water used as the auxiliary liquid, but with mercury as the auxiliary liquid proportionally (to its specific weight) higher pressures may be obtained. The above described arrangement may be used therefore for obtaining considerable pressures with small sized machines.

Internal Combustion Engines

INTERNAL-COMBUSTION ENGINES IN THE OIL INDUSTRY (*Die Verbrennungskraftmaschinen in der Erdöl-Bohrindustrie*, Neumann. *Zeits. des Internationalen Vereines der Bohringenieure und Bohrtechniker*, vol. 19, no. 20, p. 233. October 15, 1912. 5 pp., 11 figs. *d*). From a paper by the author read before the International Society of Drilling Engineers and Machinists in Berlin, on the application of internal-combustion engines in drilling for oil. The author points out the advantages of having

engines which can work equally well on natural gas and liquid fuel, and describes in detail the Deutz engine which satisfies this condition.

POWER PRODUCTION IN GASWORKS (*Die Krafterzeugung in Gaswerken*, A. Krauss. *Journal für Gasbeleuchtung*, vol. 55, nos. 37 and 38, pp. 901 and 925. September 14 and 21, 1912. 11 pp., 7 figs. *gp*). The author claims that German gas works do not make sufficient use of coke breeze and other fuel refuse which, as he shows, may be well used for the production of power; he quotes the American practice, and discusses in detail the McLean process.

A SIX-CYLINDER V-MOTOR AT 60 DEG. (*Le moteur a 6 cylindres en V a*

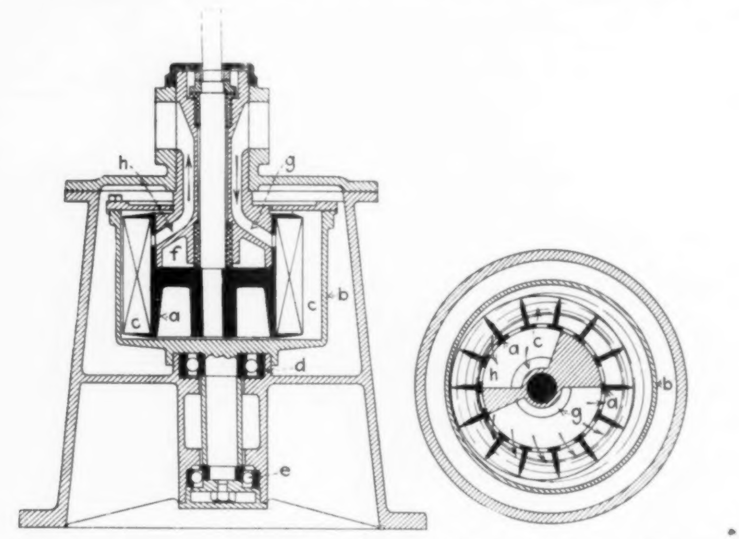

FIG. 3 BLOWER OF THE INTERNATIONAL ROTARY MACHINE COMPANY OF BERLIN

60°. *La Technique automobile et aérienne*, vol. 7, no. 82, p. 153, October 15, 1912. 3 pp., 4 figs. *t*). Theoretical investigation of a six-cylinder motor in V with the arms of the V at 60 deg., its order of ignition, and balancing.

MODERN PROGRESS AND EXPERIENCES IN THE TECHNICAL APPLICATION OF COAL TAR DERIVATIVES FOR THE PRODUCTION OF HEAT, POWER AND LIGHT. (*Neuere Fortschritte und Erfahrungen in der technischen Verwendung der Teerprodukte für Heiz-, Kraft- und Lichtzwecke*, A. Dahm, *Zeits. für angewandte Chemie*, vol. 25, no. 40, p. 2049. October 4, 1912. 9 pp., 14 figs. *dg*). A general discussion of the application of coal tar products and the use of coal tar itself as a fuel, with the description of some of the standard apparatus used in this connection.

THE GAS TURBINE (*Über die Gasturbine*, Hans Holzwarth. *Journal für Gasbeleuchtung*, vol. 55, no. 39, p. 949. September 28, 1912. 7 pp., 14 figs. *dt*). Description of the Holzwarth gas turbine (cp. The Journal,

February 1912, p. 303), and some controversy with Professor Stodola (cp. The Journal, September 1912, p. 1384). The author points out that if steam is used in gas turbines to reduce the temperature of the explosive mixture, as proposed by Davey (*The Engineer*, March 8, 1912 and ff.), the sulphur derivatives in the gaseous mixtures will pass into hydrates, and form compounds powerfully attacking the metal parts of the turbine, and it is practically impossible to regulate the injection of water with such a precision as to have in the turbine at all times only superheated steam. As to the use of convergent-divergent nozzles in gas turbines, the author states that his experiments have shown that in most cases such a nozzle is entirely unadapted for use in gas turbines; gas turbines do not have nozzles in the strict sense of the term, but use single plane parallel outlet openings of which the efficiency is independent of the pressure fall, and superior to that of a nozzle. As to the supposition that the gas turbine wheel has little efficiency owing to the variable velocity of the gas jet, the author states that his tests have shown that it is not materially below that of the steam turbine, for although the decreasing velocity of the jet is theoretically an unfavorable factor, there must be some other factors which counteract its influence.

As to the possibility of the gas turbine in its present state of development being commercially applied, the author agrees that the peak values of its efficiency curve are below those of some other prime movers, but points out that the commercial applicability of an engine is not determined by the peak values of its curve, but by the overall *commercial* economy of application. At full load the reciprocating gas engine is nearly twice as efficient as the steam turbine, but the latter is widely applied simply because the usual loads are only about 50 per cent of the maximum (this applies to steel plants only). The gas turbine, as has been shown by the tests, may use gas direct from the scrubber, without passing it through a dry cleaner, and without injuring thereby the gas admission valves; there is some deposit of dust and small particles of coal in the combustion chamber, but since no oil reaches the combustion chamber, this deposit does not cling to the walls, as in the case of reciprocating gas engines, and generally gives no trouble. No corrosion or erosion has been observed at the nozzle valves; the nozzles and blades become rapidly covered with a hard and resisting skin of iron oxide-oxidul, and after that are no more attacked by the hot gases. As to the overall commercial economy, the author calls attention to the fact that amortization, interest, attendance, etc., in steel plants, has been found to be 55 per cent of the cost of fuel in the case of steam turbines, and 245 per cent in that of reciprocating gas engines, and the author believes that for gas turbines the steam turbine ratio will hold. He states further that his gas turbine can be driven, in addition to gas, with the same liquid fuels as the Diesel engine.

Gas Turbines (*Turbiny plynove*, J. Dejmek. *Technicky Obzor*, vol. 20, no. 30, 31, and 32, pp. 221, 229 and 237, September 18, October 2 and 9, 1912. 9 pp., 17 figs. *dtA*). The author makes the usual distinction between combustion and explosion turbines, and investigates the efficiency and character-

istics of both Every gas turbine requires a compressor which takes up the heoretical amount of work L_c, or the actual amount of work $\frac{L_c}{\eta_e}$ where η_c is the efficiency of the compressor. If L_t be the theoretical output of the turbine without compressor, and L_z that with the compressor, then

$$L_z = L_t - L_c$$

If, further, η_t be the efficiency of the turbine without compressor, the effective work of the turbine without compressor is $\eta_t L_t$, and that of turbine with compressor

$$L_e = \eta_t L_t - \frac{L_c}{\eta_c}$$

while the overall efficiency of a turbine with compressor is

$$\eta = \frac{L_e}{L_z} = \frac{\eta_t L_t - \frac{L_c}{\eta_c}}{L_t - L_c} = \frac{\eta_t - \frac{L_c}{L_t} \cdot \frac{1}{\eta_c}}{1 - \frac{L_c}{L_t}}$$

In connection with the combustion gas turbine the author investigates the following two processes: (*a*) adiabatic compression and adiabatic expansion, and (*b*) isothermic compression and adiabatic expansion. In the following let T_1 be the absolute temperature at the end of compression, T_2 at the beginning of expansion, T_3 at the end of expansion, and T_o at the beginning of compression. Since the amount of heat and work brought in must be equal to that of heat and work taken away

$$L_t - L_c = Q_1 - Q_2$$

where Q_1 is the amount of heat brought in, and Q_2 that escaping through the exhaust, whence

$$Q_1 = c_p\,[T_2 - T_1], \quad \text{and} \quad Q_2 = c_p\,[T_3 - T_o]$$

The absolute heat efficiency is

$$\eta_a = \frac{Q_1 - Q_2}{Q_1} = \frac{c_p[T_2 - T_1] - c_p[T_3 - T_o]}{c_p[T_2 - T_1]} = \frac{T_2\left(1 - \frac{T_1}{T_2}\right) - T_3\left(1 - \frac{T_o}{T_3}\right)}{T_2\left(1 - \frac{T_1}{T_2}\right)}$$

but since in adiabatic compression or expansion

$$\frac{T_1}{T_2} = \frac{T_o}{T_3}$$

hence

$$\eta_a = \frac{T_2 - T_3}{T_2} = 1 - \frac{T_3}{T_2} = 1 - \frac{T_o}{T_1}$$

which shows that the heat efficiency depends on the temperature ratios and not on the maximum temperatures used in the process. It is further shown that the following must hold:

$$\frac{L_c}{L_t} < \eta_t \cdot \eta_c$$

since otherwise no work would be produced. But the following equation is also correct:

$$\frac{L_c}{L_t} = \frac{T_1 - T_o}{T_2 - T_3}$$

and since for the case of adiabatic compression or expansion

$$\frac{T_1}{T_2}=\frac{T_o}{T_3}$$

therefore

$$\frac{L_c}{L_t}=\frac{\frac{T_o}{T_3}-\frac{T_o}{T_2}}{1-\frac{T_o}{T_1}}$$

which, for the usual range of temperature, may be written with sufficient correctness in the following form:

$$\frac{L_c}{L_t}=\frac{T_o}{T_3}$$

This shows that the chief condition for the production of any work at all is that

$$\frac{T_o}{T_3}<\eta_t\,.\,\eta_c$$

Taking a numerical example, and substituting for η_c 0.8, for η_t 0.7, and for T_o 300 deg. cent., the following must hold

$$\frac{300}{T_3}<0.7\times 0.8$$

or

$$T_3>535 \text{ deg. cent.}$$

Process of Isothermic Compression and Adiabatic Expansion. In this process $T_o=T_1$. The loss of heat in the process with isothermic compression is expressed by the equation

$$Q=Q_2+Q'_2$$

where Q_2 is the heat lost through the exhaust, and Q'_2 that lost through compression, the latter being expressed by the equation:

$$Q'_2=ART_o\, l_{nat}\frac{P_1}{P_o}$$

Substituting this value in the equation for the absolute thermal efficiency

$$\eta_a=\frac{c_p(T_3-T_1)-c_p(T_3-T_1)-ART_1\, l_{nat}\frac{P_1}{P_o}}{c_p(T_3-T_1)}$$

But as to the effective work of the turbine, the following must hold:

$$\frac{L_c}{L_t}<\eta_c\,\eta_t$$

Since, however, it was shown above that

$$L_c=RT_o\, l_{nat}\frac{P_1}{P_o}$$

and

$$L_t=R\,.\,\frac{k}{k-1}[T_3-T_2]$$

therefore

$$\frac{L_c}{L_t}=\frac{k-1}{k}\,\frac{T_o}{T_3}\,\frac{l_{nat}\frac{P_1}{P_o}}{\frac{T_3}{T_2}-1}$$

Substituting corresponding values from equation

$$\left(\frac{T_2}{T_3}\right)^{K} = \left(\frac{P_1}{P_0}\right)^{K-1}$$

the following is finally obtained

$$\frac{k-1}{k} \cdot \frac{T_0}{T_3} \cdot \frac{1_{nat} \dfrac{P_1}{P_0}}{\left(\dfrac{P_1}{P_0}\right)^{\frac{k-1}{k}} - 1} < \eta_e \cdot \eta_t$$

which shows that with constant T_3, T_0 is a function of the pressures p_1 and p_0.

The author treats in the same manner the explosive gas turbine, this part being omitted partly owing to lack of space, partly because the theory of the explosive turbine is considerably better known through the publications of Holzwarth, Davey, H. H. Suplee, and others.

The article further discusses the heat entropy diagrams for the gas turbines, and describes the Holzwarth turbine.

Diesel Engine Building at the Germania Shipbuilding Yard (*Der Dieselmotorenbau auf der Germaniawerft*, C. Regenbogen. *Die Gasmotorentechnik*, vol. 12, no. 7, p. 113. October 1912. 3½ pp. *gh*). A historical sketch of Diesel engine building at the Germania shipbuilding yard, one of the largest in Germany, and some considerations on the design, mainly that of large Diesel engines for marine purposes. The problem of *cooling the piston head* was at first solved by using as a cooling medium lubricating oil, because if it should happen to leak into the cylinder, it could do no particular harm there, as would water, particularly sea water. It was found, however, after a series of comprehensive tests that in the case of very large two-stroke cycle motors water as a cooling medium gives better results when carefully selected and suitably designed apparatus is used for the distribution of the liquid.

Experiments have shown that double-acting Diesel engines may now be built without much difficulty at 2000 h.p. up per cylinder. In fact, the firm has constructed at considerable expense a large two-stroke cycle double-acting stationary single-cylinder engine with scavenging pump at the side of the main cylinder, and it proved a success. As regards the improvement of specific efficiency of two-stroke cycle engines, the limits of piston velocity have been practically reached, and further progress may be expected only in improvements of the compression of gas mixture in the cylinder and still better atomization of fuel.

The Micro-Indicator (*Der Mikro-Indikator*, O. Mader. *Der Motorwagen*, vol. 15, no. 17, p. 632. September 30, 1912. 4 pp., 19 figs. *d*). Description of a special *indicator* invented by the author *for use with high-speed small internal-combustion engines*, where the ordinary indicator cannot well be used. Attempts have been made to use optical indicators for pressure recording but their disadvantage is that their record must be made photographically, and that leads to the diagram lines being

of very uneven distinctness, and being underexposed in fast moving machinery, and overexposed in indicating slow-speed engines. The author's *micro-indicator*, like the early steam indicators, has a short piston stroke and direct recording, in this case, however, made with a sharp steel point on a soot blackened glass; the fine lines are then magnified under a microscope, outside of the engine installation proper. Fig. 4A schematically represents the gear which allows the indicator record to be made by minute sidewise motions of the light steel point. The piston rod has at the top a flat plate *a* which is in gliding contact with the end of

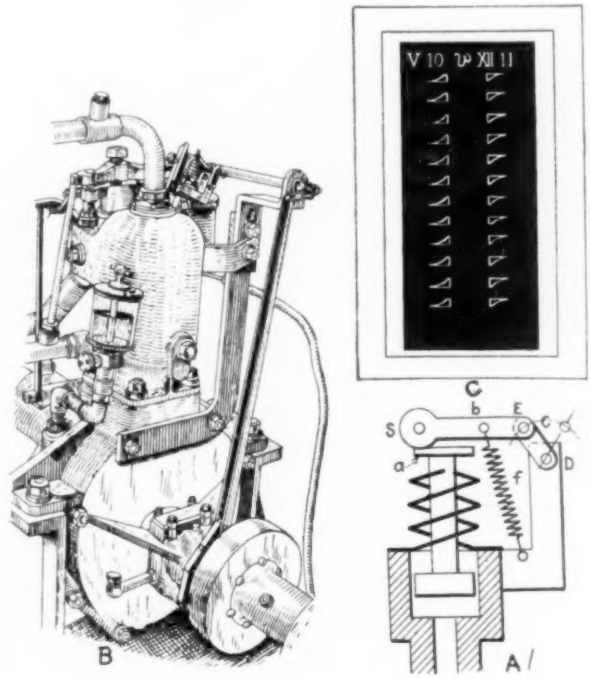

Fig. 4 Mader Micro-Indicator, Its Drive and Diagrams in Natural Size

the rod *b*. The point *s* of the recording style lies exactly in the axis through the center of the circular end of the rod *b* of which the second end *E* is actuated by the lever *c* swinging about *D*. To keep the rod *b* always in gliding contact with the end of the piston rod, and to avoid lost motion in the gear, the many-coiled spring *f* is introduced. Since many guide points, even with the best adjustment, are apt to produce excessive friction, the parts in this indicator are all guided at no more than two points; thus, the piston is guided below by the cylinder wall, above by the double wound spring, the spring, rod and piston being combined in one piece, and, should another scale be required for the diagrams, must all be changed together; this, however, eliminates all

possibilities of their getting loose in operation or being incorrectly put together at the beginning.

An important part of the micro-indicator is the diagram holder, a U-shaped frame rotatable about a fixed axis; the soot blackened glass is slipped in from above and held fast by a spring. The simplest drive, with as few joints as possible, is used, e. g. a rocking drive (Fig. 4B). To avoid large errors in the diagrams, the setting of the drive must be carefully made not only as regards dead centers, but also with respect to the average piston position at which the recording style is instantaneously at rest previous to changing its direction of motion.

The diagrams are magnified by an ordinary microscope with a 1:40 rate of magnification, which is sufficient for an estimate of the diagram by inspection. If measurements are to be made, the diagrams are magnified either photographically, or drawn to a larger scale by means of a special reflecting and magnifying device.

The micro-indicator may be used for the determination of the indicated horsepower of a high-speed internal-combustion engine (600 to 3000 r.p.m.); the glass on which the records are made may be cleaned, covered by a new layer of soot or lampblack, and used over and over again.

Influence of the Speed of Combustion on the Efficiency of a Gas Engine (*Influence de la vitesse de combustion sur le rendement d'un moteur à gaz*, E. Mérigeault, *Comptes Rendus des séances de l'Académie des Sciences*, vol. 155, no. 15, p. 644. October 7, 1912. 3 pp., 3 figs. *t*). The author establishes a theory of the gas engine which may be applied independently of the nature of the gaseous medium and of its molecular contraction produced by combustion. He starts from a previously established equation

$$AT_u = L_v - -\int_{T_B}^{T_E} c\,dT - p_a(V_E - V_B)$$

which is true whatever the nature of combustion, and in which T_u is the work produced by the engine during a complete cycle (two revolutions); L_v the calorific value, at constant volume, of the combustible admitted during one piston stroke; q the quantity of heat given up to the walls during the time between the end of the admission B to the beginning of the exhaust E; T and T_E the temperatures, supposedly uniform, at those two instants; c the specific value, at constant volume, of the whole mass of gases contained in the cylinder at the end of combustion; E_B and V_E volumes at the instants B and E respectively. The author proceeds to prove the following theorem (modification of Carvallo's, but applicable to all gases): If there be two motors having walls impermeable to heat (i.e. with $q = O$), and with volumes V_E and V_B equal respectively, absorbing at each stroke the same quantity of combustible gas, and *working between the same limits of pressure;* if in one of these two cylinders the combustion is at constant pressure, while in the other it follows some other law, but is complete at the moment of exhaust, *the first has a better efficiency.* Let *BCDE* and *BC' D' E'* (Fig. 5) be the diagrams of these two motors, where *DE and D' E'* are two adiabatic curves of the

same gaseous system (completely burned gas). The author first proves that E' cannot be above E, as in the diagram on the left, and that it must therefore be below it, as on the other diagram. Hence $T_{E'} > T_E$ and consequently

$$\int_{T_B}^{T_E'} cdT > \int_{T_B}^{T_E} cdT$$

But from the assumption of equal limits of pressure in the theorem, $C'D'$ must be tangent to CD, and

$$AT_u = L_v - \int_{T_B}^{T_E} cdt - Ap_a (V_E - V_B)$$

$$AT_u - L_v \int_{T_B}^{T_E'} cdT - Ap_a (V_E - V_B)$$

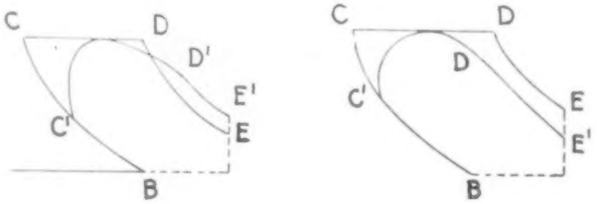

FIG. 5 INDICATOR DIAGRAMS

and from this and the preceding inequality is deduced

$$T_u > T'_u$$

which shows not only the comparative values of the two efficiencies, but also the relative position of the two diagrams.

MIXED COMBUSTION-MOTOR SABATHÉ (*Motore à combustione mista Sabathé. L'Industria*, vol. 26, no. 41, p. 645. October 13, 1912. 3 pp., 8 figs. *d*). Description of the Sabathé engine, double-acting, four-stroke cycle, of the *mixed combustion* type, i.e. with the admission of the fuel, after the compression of the air, so regulated that combustion occurs first at constant volume, and then at constant pressure. In an explosion motor (Fig. 6 L) the heat which has to be transformed into work is produced instantaneously in the cylinder, and there is an instantaneous rise of pressure AB at constant volume. In a slow combustion motor (Fig. 6 M) the production of heat takes place during a quite appreciable length of time, and at about the same rate as it is transformed into work, the temperature of the fluid remaining therefore nearly constant; the period of combustion is shown by AB, the working process being that of the Diesel engine. The *Sabathé engine* follows a mixed process (Fig. 6 N): part of the heat is produced in AB at constant volume, with rise in pressure and temperature, and part in BC at constant pressure. Theoretically the Sabathé motor is superior or at least equal to the Diesel engine, as the author shows by an analysis of its thermal diagram.

The most interesting part of the engine, the needle device which helps to produce mixed combustion, is shown in Fig. 6, O: the needle *A* has a conical tip fitting into a conical orifice in a bush held at the bottom of the cylinder by springs; a cam at a convenient moment lifts the needle *A* which in its turn raises the valve *S*, by means of the wipers *T*, when it has gone a certain distance in its upward motion. The fuel passes through the passage *B* and at first fills the chamber *G* below the valve *S;* the compressed air for the atomization of the fuel arrives by the duct *D* and reaches the chamber *G* through a groove cut along the valve

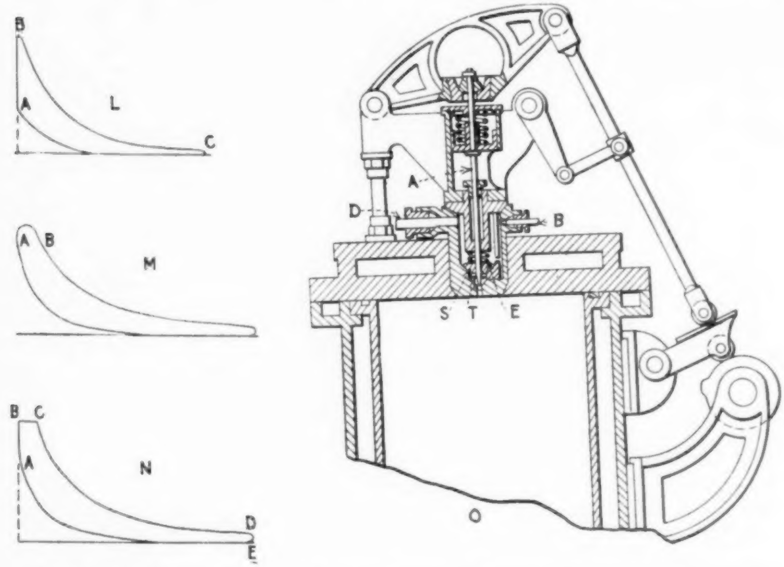

Fig. 6L, M, N Diagrams of Various Types of Internal-Combustion Engines
O Tappet Gear of the Sabathe Engine

S. The working process is as follows: at low speed, the fuel which nearly fills the chamber *G* is injected into the cylinder when the needle moves upward and a little before it reaches the neutral position, and explodes at constant volume; when the output of the engine reaches a certain amount, the chamber *G* cannot hold all the fuel that is required, and some of it accumulates in the chamber *E*. Therefore, when the needle is lifted, first the fuel in *G* is projected into the cylinder, and explodes at constant volume, and then, after the wipers *T* have raised the valve *S*, the fuel from *E* is admitted into the cylinder, and is consumed there in accordance with a law depending on the shape of the cam, and nearly achieving combustion at constant pressure. For the atomizer proper of the Sabathé engine see H. R. Setz, Oil Engines, Trans. AM.Soc.M.E., vol 33, 1911, p. 868.

The Sabathé engine can use any kind of liquid fuel, from petroleum to the heavy and cheap oils, and consumes, for large motors, less than 0.2 ng.

(0.44 lb.) per effective h.p., and in small motors from 230 to 0.24 ng. (0.50 to 0.53 lb.).

A New Freighter Equipped with Diesel Engines (*Un nuovo piroscafo da carico con motori Diesel*, G. Supino. *L'Industria*, vol. 26, no. 40, p. 631. October 6, 1912. 3½ pp., 13 figs. *d*). Description of the Diesel engine freight carrier "Monte Pinedo," 4000 register tons. For a complete description see *Motor Boat*, October 10, 1912, p. 10.

Machine Shop

The Oxy-Acetylene Welding Burner, Its Operation and Constructional Requirements (*Der Acetylen-Sauerstoffschweissbrenner, seine Wirkungsweise und seine Konstruktionsbedingungen. Acetylen*, vol. 15, no. 16, p. 145, in the pagination of the appendix *Autogene Metallbearbeitung*, 5 pp., 3 figs. *et*). Abstract of a doctor's thesis under the above title presented by Hans Ludwig at the Technical High School of Berlin, and covering besides general considerations on the theory of burners for autogenous welding, the description of the test arrangements, calibration of instruments, and test data. The following are the most important conclusions of the author's investigation: (*a*) the gas mixture in the burner should consist at the moment of combustion of equal percentages of oxygen and acetylene, while the velocity of the flow of gas must vary, in accordance with the type of burner, from 80 to 140 m (262 to 460 ft.) per sec.; (*b*) the cross-sections of the passages in the burner must be adjustable to make possible an admission of an excess of acetylene in order to regulate the ratio of gas mixture which may be changed through the heating of the tip of the burner; (*c*) the preheating of oxygen produces increase in the velocity of the flow of the gas, and decrease of the mass of oxygen flowing through the nozzle per unit time; (*d*) the tests have established the fact that the mixture of the gases at the burner nozzle produced by a simple mixing chamber is perfect, and there are no separate streams of oxygen and acetylene; (*e*) the temperature of the welding flame is estimated as between 3000 and 3400 deg. cent. (5432 to 6152 deg. fahr.). The experiments have further shown that with low-pressure burners the mixture ratio may be varied by regulating the oxygen supply only, since, although the acetylene supply may be reduced by throttling, it cannot be always increased as desired. As to the velocity of flow of gas through the nozzle it was found that it is right when there is no back firing during the welding; the particular velocity for each burner has to be established by trials, within the limits set above.

The tests have established a complete absence of standards for regulating the gas consumption of burners per unit of work done, and some burners consume nearly 50 per cent more gas than others for the same amount of work done; with the existing difficulties of measuring the temperature of the flame it is, however, difficult to determine the actual efficiency of the different types. The author discusses in detail the influence of various proportions of passages in the burner on its efficiency, and recommends certain ratios.

TESTS OF AUTOGENOUS WELDING (*Essais sur la soudure autogène*, Desjuzeur, La Houille Blanche, vol. 11, no. 8, p. 201. August 1912. 4 pp. *e*). The article is based partly on the old tests of Professor Bach of Stuttgard, partly on recent tests made for the author, who is director of the Lyons Association of Owners of Steam Machinery, by Professor Bach and the laboratory of the Steel and Foundry Company of Firminy, on test pieces supplied by the Dissolved Acetylene Company of Marseille, France. These tests have shown that a well-made weld does not create a weak point as far as resistance to static effort is concerned. In some cases where the excessive thickness produced at the welded spot has not been planed off, the rupture occurred elsewhere; where it has been removed by planing, the rupture occurred at the weld, but the stress in all cases has been but slightly below the usual breaking stress for the given metal. The elongations, however, have been markedly reduced, 39 to 47 per cent for bars with excessive thickness at the weld not planed off, and 67 per cent for planed-off bars. Tension tests at 200 deg. cent. (392 deg. fahr.) have shown that at this temperature the elongation in welded sheets is still below that of the unwelded metal, and it would be dangerous therefore to accept, as some do, that the ductility of the metal in case of boilers is improved by the heating to which the sheets are subjected. It was further found that, probably owing to the action of rapid cooling at the welded joint, the metal there is considerably harder than elsewhere, and that the welded joint has a lower resistance to shocks. The resilience at the weld is approximately only one-seventh of that of the unwelded part of the sheet, which the author ascribes, from data furnished by the chemical analysis, to the presence of a large amount of phosphorus in the welded joint, which may again be due either to the quality of the iron in the melted bar, or to the presence of hydrogen phosphate in the acetylene.

From a microscopic investigation and other data the author expressed a conviction that it would hardly be possible at the present time to have obtained better autogenously welded joints than those which were submitted to his tests. It is therefore difficult to say what may be the strength of the less carefully made joints, especially in jobs on marine boilers where the welder works under extremely unfavorable conditions, lying on his back, cramped as to space, and all the time exposed to the intense heat from the burner.

USE OF CONCRETE IN MACHINERY FOUNDATIONS (*Anwendung von Beton zu Maschinenfundamenten*, *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 38, p. 1546. September 21, 1912. 3 pp., 8 figs. *dp*). Supplied by the Information Bureau for Concrete Constructions in Heidelberg, Germany. The article describes how concrete foundations may be changed with the change of machinery, partly using the old foundations for the new purpose. A good plan is to drill holes by a compressed air drill, and then break the concrete by hand bars, or to remove the concrete by explosives. The broken material may be easily removed by hand and used again. The article also gives detailed instructions as to the concrete mixture and manner of laying the foundation.

MAKING PATTERNS FOR SINGLE AND DOUBLE AUTOMOBILE CYLINDERS (*Anfertigung von Modellen zu einfachen und doppelten Automobilzylindern*,

J. Biller. *Werkstattstechnik*, vol. 6, no. 20, p. 525. October 15, 1912. 4 pp., 13 figs. *p*). Detailed instructions for making patterns for automobile engine cylinders, with data on the cost of same in Germany.

Crystallization by Reheating of Thin Drawn Metal (*Cristallisation par recuit des métaux écrouis*, F. Robin. *Comptes Rendus de l'Académie des Sciences*, vol. 155, no. 13, p. 585. September 23, 1912. 2 pp. *e*). The author has found by experiments reported in the article that when a thin drawn metal is reheated, the size of its crystals is a function of the temperature and duration of reheating, but with the same duration of reheating, the *size of the crystals does not grow regularly with the temperature of reheating*, since neither the largest grains are obtained with the highest temperatures of reheating, nor the smallest grains with the lowest temperatures. Generally the grains which are large in the proximity of the temperature of melting, at first decrease rapidly with the temperature, and then remain stationary for a time. Impurities have an important influence in reducing (except in the case of zinc alloyed with copper) the size of the crystals without materially affecting the temperature at the beginning of reheating.

Process for the Manufacture of Iron and Steel and Furnaces for using It (*Procédé pour la fabrication du fer et de l'acier et four pour la mise en pratique. La Métallurgie*, vol. 44, no. 40, p. 613. October 2, 1912. 1 p., 7 figs. *d*). A new process for the manufacture of iron and steel patented by Meyer Davidsen. The disadvantage of the regenerative furnace consists in the heat losses involved in the regeneration process, and the necessity of varying the direction of the flow of air frequently. *In Davidsen's process finely powdered coal is burned above the metal bath.* All the heat contained in the coal is instantly developed in the very laboratory of the furnace, and all losses in producing the gas in gas producers and preheating it are entirely eliminated. A further advantage of the new process consists in the method of communicating the heat to the metal. The flame produced by burning finely ground coal consists of an extremely large number of minute incandescent particles having a high radiating capacity; there is therefore in the first instance no need to bring the surrounding air to the temperature of the coal particles, the heat being communicated by radiation, and not by convection, and in the second place the flame may be kept high enough above the metal bath to prevent its contamination by impurities from the coal, and that permits of doing away with the arch which at best is only a source of trouble and expense. The temperatures obtained in such furnaces are claimed to be very high, closely approaching those of the electric furnace. By the elimination of frequent reversals of the direction of the flame various parts of the furnace are kept always at the same temperature. The rate of the flow of air must be large enough to prevent deposits of ash in the furnace proper. The article gives the details of the furnace construction; it is to be continued.

Sand-Blasting Machines and Their Application to Cleaning Iron and Other Structures (*Sandstrahlgebläse und deren Anwendung zur Reinigung von Eisenkonstruktionen und sonstigen Bauwerken*, W. Eckler. *Der*

Eisenbau, vol. 3, no. 10, p. 372. October 1912. 6 pp., 7 figs. *deh*). A general and historical sketch of the *sand-blasting machine practice*. The author quotes data of tests which show that sand-blasting is superior to steel brushes, or to repeated bending for cleaning of iron. As to the efficiency of compressed air sand-blasting machines, he gives the following information. With average pressure of 1 to 1.2 atmospheres, and good sharp sand the following areas per hour have been cleaned:

Diameter of Nozzle.		Area Cleaned.	
Mm	In.	Qm.	Sq. ft.
6	0.236	2 to 3	21.5 to 32.3
10	0.393	4 to 6	43.0 to 64.5
16	0.629	10 to 15	107 to 160

Cp. also Wm. T. Magruder, Tests of a Sand-Blasting Machine, Trans. Am. Soc. M. E., 1911, p. 821.

Mechanics

THEORETICAL CONDITIONS FOR THE INSTALLATION OF CHANGE OF SPEED (*Conditions théoriques de l'établissement d'un changement de vitesse*, G. Lienhard. *La Technique automobile et aérienne*, vol. 7, no. 81, p. 132. September 15, 1912. 3 pp., 4 figs. *mt*). A theoretical investigation of the principles of *speed changing*, mainly with regard to automobile engines. The author comes to the following conclusion: the car must be so constructed and *nn'* (reduction due to the change speed gear box times reduction due to the pinion and crown wheel of the differential) so selected that the speed of the motor should correspond to its maximum capacity while the torque should be but slightly below its maximum value. With this condition satisfied, within its normal range the motor will use its maximum capacity at the highest efficiency.

A STUDY OF CARDAN SHAFT DRIVES (*Etude sur les transmissions par cardan*, A. Contet. *La Technique automobile et aérienne*, vol. 7, no. 81, p. 135. September 15, 1912. 3 pp., 5 figs. *t*). The author investigates various types of *Cardan drives*, and finds that the single joint Cardan drive, though apparently unsatisfactory, is really not so bad. When the cardan shaft is long, the joint works at small angles, and with an elastic shock absorber suitably placed, may give very good results: the above mentioned precautions reduce the wear of the tires due to speed variations to a minimum, while the simplicity and ease of operation of the simple cardan drive cannot be neglected. The author further examines attempts to compensate the speed variations due to the first cardan joint by introducing a second one with equal and opposite variations. Such a compensation is absolutely perfect when the driving and driven shafts are strictly parallel, while the intermediate shaft has both its pinions in the same plane (Fig. 7A): the original and the compensating curves are similar throughout though of opposite signs, and the resultant is therefore the diameter of the circle itself. Such an arrangement has been tried on an automobile by Mildé-Gaillardet in France, but it was found to be too complicated in execution; besides, the large number of joints favored the appearance of play, and that produced chattering. Still less satisfactory was the solution when it was attempted to produce compensation of the velocity variations simply by having the two extreme

shafts parallel with each other, but making with the intermediate shaft an angle β (Fig. 7B), with the pinions of the intermediate shaft in two planes normal to each other. In this figure , is the angular velocity of the driving shaft, ω_1 that of the driven shaft, ω' that of the intermediate shaft, the ratio $\frac{\omega}{\omega'}$ is expressed by the continuous thin line, the compensating ratio $\frac{\omega'}{\omega_2}$ is represented by the dotted line, while the heavy line shows the curve obtained by summing the ordinates of both curves. It has a large amplitude, and three angular points which indicate a tendency towards shocks and rapid wear of the tires on the car. The author investigates in a similar manner the cases when each of the shafts makes an angle β with the intermediate shaft, the total angle between the driving and driven shafts being 2β: if the pinions of the

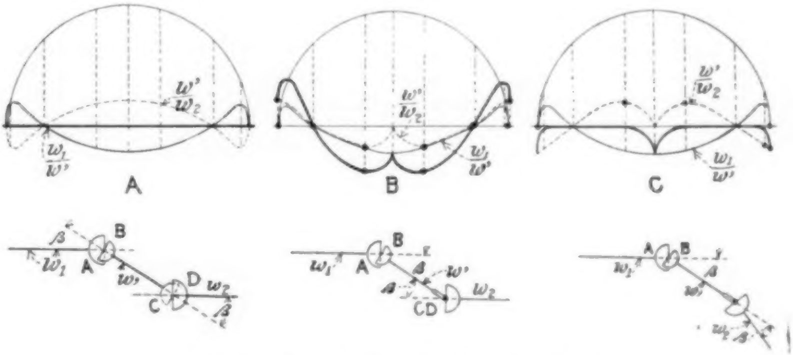

FIG. 7 CARDAN DRIVES OF VARIOUS TYPES

intermediate shaft are in the same plane, the curve shown in Fig. 7C, is obtained: in its major part it is perfectly flat and coincides with the diameter of the circle, but it has the disadvantage of having three points of angular variation where sudden changes of velocity occur; when the planes of the pinions are normal to each other, the ordinates are simply superimposed, or the ordinate of the final curve is twice that of the original, and not only is there no compensation, but all the bad effects of the original arrangements are doubled. The author believes, however, that with long shafts and small angles, the arrangement shown in *C* may work fairly well.

NEW BICYCLE BEARING (*Ein neues Fahrradlager*, W. M. *Der praktische Maschinen-Konstrukteur*, vol. 45, no. 20, p. 344. September 26, 1912. 2 pp., 2 figs. *d*). Description of the new bicycle ball bearing, without cones, used by the Deutsche Waffen- und Munitionsfabriken in Berlin, Germany.

REVERSIBLE PROPELLERS FOR LARGE OUTPUTS (*Umsteuerschrauben für grosse Leistungen*, W. Helling. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, no. 37, p. 1485. September 14, 1912. 4½ pp., 15 figs. *dt*). In-

vestigation of the theory of reversible propellers, and difficulty of their application as a function of the engine output, as well as their advantages as compared with other types of reversing gear. To prove the incorrectness of the view that reversible propellers cannot be used for outputs exceeding 200 h.p., the author describes the gear of Theodor Zeise in Altona, Germany, consisting of two reversible propellers for the normal transmission of 1200 h.p., and 1860 effective h.p. as a maximum. Such propellers are now mainly used in submarines for outputs from 100 to 1000 h.p.

On the more important Resonance Phenomena and Their Experimental Reproduction (*Über wichtigere Resonanzerscheinungen und deren experimentelle Vorführung*, R. Hartmann-Kempf. *Zeits. für den phys. u. chem. Unterricht*, no. 24, 1911, p. 325, through *Deutsche Mechaniker-Zeitung, no.* 19, p. 200. October 1, 1911. 1½ pp. *e*). Description of apparatus for the experimental reproduction of resonance phenomena, mechanical, accoustical, optical or electrical.

Pressure on the Walls in Silos and Gas Producers (*Wanddruck in Silos und Schachtöfen*, G. Lindner. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 124. 1912, p. 1, 32 pp., 42 figs. *te*). Investigation of the pressure on the walls of cylindrical containers, e. g. silos, gas producers, blast furnaces, etc. The theory of earth pressure cannot be applied in such cases directly owing to the small diameter of the structures, under consideration. The author indicates a simple graphical method for the solution of this problem.

Calculation of Arched Plates (*Berechnung gewölbter Platten*, H. Keller. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 124, 1912, p. 33. 50 pp., 54 figs. *mt*). A method for calculation and design of bodies with: (*a*) variable thickness, (*b*) variable diameter of arching, or (*c*) hole in the middle. The author solves his differential equations by an approximate "Calculus of small differences."

Heavy Belt Drives for Rolling Mills (*Über schwere Riemenantriebe für Walzwerksanlagen*, W. Schömburg. *Stahl und Eisen*, vol. 32, no. 40, p. 1655. October 3, 1912. 4 pp. 2 figs. *ce*). The author shows why belts, woven and made of thin leather tanned with oak bark in vacuo, have displaced ropes for heavy drives in rolling mills, and gives data of some tests on the efficiency of such belts. (Cp. The Journal, May 1912, p. 798.)

Reversal and Speed-Changing Devices (*Changement de marche et de vitesse, G. R. Revue de mécanique*, vol. 31, nos. 2 and 3, pp. 162 and 267, August 31 and September 30, 1912. 50 pp., 177 figs. *d*). A list of patents, American and foreign, on reversal and speed-changing devices, with drawings and brief descriptions.

Testing and Estimation of Lubricants (*Prüfung und Bewertung der Schmiermittel*, Professor Holde. *Zeits. des Vereines deutscher Ingenieure*, vol. 56, nos. 35 and 36, pp. 1411 and 1460. August 31 and September 7, 1912. 9 pp., 7 figs. *hp*). Paper read by the author before the Lower Rhine Section of the Verein deutscher Ingenieure. A brief historical sketch of the introduction of modern lubricants in Germany and Austria

is given, followed by an extensive discussion of the conditions which lubricants must satisfy for particular purposes. There were cases of explosions occurring in compressor cylinders and due to the presence of carbon deposits from the lubricating oil, even though viscous mineral oil containing only a few per cent of neat's-foot-oil was used. It is possible, however, that in such cases proper cooling of the compressor cylinder was neglected, and a violent oxidation by the compressed air took place, or it may have been that the oil was not thick enough or had too low a flash point. Thus, in one case submitted to the Royal Testing Laboratory, explosions were eliminated when for oil having a flash point of 250 deg. cent. (482 deg. fahr.) was substituted one with a flash point of 300 deg. cent. (572 deg. fahr.).

Deposits in the cylinders of steam and large gas engines must not always be credited to the lubricating oil. In the deposits on steam engine cylinders iron particles and particles of iron oxides have been found which may have come from the superheater, while the presence of large grains of sand and metal shavings would indicate that at least some of the deposit is due to the action of the piston which in its rapid motion takes off all the irregularities and impurities of the cylinder surface; there are as a rule more deposits in the case of engines working with superheated steam. In the investigation of the deposits in the mixture valves of a large coke-oven gas engine made at the Royal Testing Laboratory by H. Schlüter, there were found no traces of oil in the deposits which consisted of 2/3 coal tar derivatives, and 1/3 inorganic matter, such as sand, iron particles, etc., indicating that the gas used was not sufficiently clean. On the other hand, oil is often the cause of trouble; thus, in the case of the resinification of an oil used in a turbine it was found that it contained an excessive amount of soapy matter (corresponding to 0.07 per cent ash, while the percentage of ash in clean machine oil must not exceed 0.01). The oil was also found to contain an excessive amount of organic acids, and the soapy matter was probably produced by the interaction between these acids and the iron of the machine.

The author discusses the modern views as to the chemical testing of lubricants, in accordance with the views of Marcusson and Schwartz, and describes the methods and apparatus used in testing lubricants.

BALL BEARINGS IN MECHANICS (*Kugellager in der Mechanik*, A. Bauschlicher. *Deutsche Mechaniker-Zeitung*, no. 18, p. 189, September 15, 1912. 5 pp., 4 figs. *dh*). General, partly historical discussion of the design and application of ball bearings, telling how the Deutsche Waffen- und Munitionsfabriken in Berlin, with Professor Stribeck's assistance, have gradually developed the modern form of ball bearings (for Stribeck's formulae see W. C. Unwin, The Elements of Machine Design,. London 1909, p. 333). The author makes the following recommendations for putting in ball bearings: (*a*) if two or more ball bearings are used conjointly, only one of them should be fixed tight axially, i. e., the outer race of one bearing should be fixed with practically no play while all the other races of the bearings should have a longitudinal play of 2 to

5 mm (0.078 to 0.196 in.) in accordance with the length of the shaft and its probable expansion; (*b*) as a rule, the inner races are fixed pretty tightly on the journal of the shaft, but heavy one-sided driving-on should be avoided because it expands the race and prevents easy running. The outer race is gently introduced into the bore in the engine frame, or corresponding place, there being no need to have this race fixed in any way since the friction in the bearing is so slight that there is practically no tendency for the outer race to turn with the balls; (*c*) in placing footstep bearings care should be taken that there be no friction between the fixed race and the shaft which passes through it.

The following recommendations are made as to the lubrication of ball bearings and keeping them free from dust: (*a*) only lubricants free from acids should be used, while vegetable oils (e.g. rape-seed oil) and animal fats should be avoided, because they are apt to become rancid and produce rusting of the bearing; (*b*) for high-speed shafts very fluid

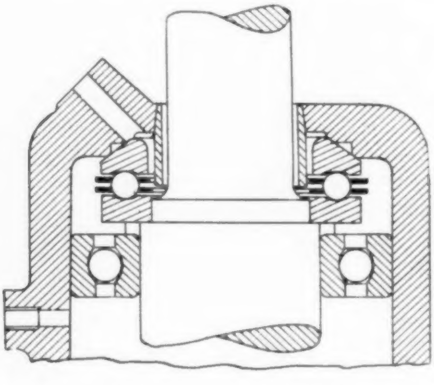

FIG. 8 OILING ARRANGEMENT IN A FOOTSTEP BALL BEARING

mineral oils are preferable and more viscous oils for slower shafts; for exceptionally rapidly revolving ball bearings oil bath lubrication should be used, with not too much oil; where the shaft passes through the bearing, the oil level must not reach the shaft since the bearing itself and particularly the cages produce powerful eddies in the oil; (*c*) for the very large number of cases where the shaft passes through the bearing, single or double safety chambers (stuffing boxes in the case of double chambers are recommended); the outer one, or the one away from the bearing, is packed with felt, while the one towards the bearing serves simply for catching the oil, and is provided with a hole for letting the oil flow back on the bearing; (*d*) for the oil bath lubrication of footstep bearings the arrangement shown in Fig. 8 is recommended, since it contains a special outside bush which helps to keep the ball bearing immersed in oil, the latter being kept always at a certain predetermined level.

The author points out that although a ball bearing can run for a

certain time without any lubrication at all, it becomes heated and wears rapidly away; its consumption of oil is only 1/10 to 1/15 of what an equivalent bearing with sliding friction would take. A further advantage of ball bearings is that should they become worn it is only the bearing that is injured, and not the shaft.

Refrigeration

FLANGE STANDARDS (*Flanschennormalien, Zeits. für die gesamte Kälte-Industrie*, vol. 19, no. 10, p. 198. October 1912. 5 pp., 2 figs., and one table of standard dimensions. *g*). Draft of *Flange Standards for ammonia and sulphurous oxide piping* in refrigerating plants submitted to the German Refrigeration Association by its Committee on Flanges, with a table of proposed dimensions. The Editor calls attention to the fact that the committee based its standards on the standards for flanges of the Verein deutscher Ingenieure for High Pressure Steam of 1900; the Verein, however, lately adopted new flange standards to be known as 1912 Flange Standards for High Pressure Steam.

Shop Management

SEPARATION INTO ELEMENTS AND MEASUREMENT OF A WORKMAN'S EFFORTS, AND THEIR PRACTICAL IMPORTANCE (*Die Zergliederung und Messung von Arbeitsleistung und ihre Bedeutung fur die Praxis*, A. Neuburger. *Werkstattstechnik*, vol. 6, no. 20, p. 529. October 15, 1912. 3 pp., 8 figs., *e*). The French Government granted some time ago a fund of approximately $1000 for the investigation of the problem of scientific management, and A. Imbert of the University of Montpellier has, in connection with this grant, carried on a series of investigations the data of some of which are published in this article. His aim was to obtain exact measurement of the amount of work spent by the workman on his job, and to this end he designed a series of apparatus. As an example may be quoted his study of the process of transporting sacks by a wheelbarrow. The efforts of the workman are divided as follows (Fig. 9A): (*a*) action of the right foot on the axis of the wheel to place the wheelbarrow in an upright position; (*b*) the action of the right hand on the sack producing its tilting; (*c*) simultaneously with the last, action of the left hand on the left hand-bar of the barrow to load the sack on the barrow; (*d*) initial effort applied at the hand-bars to start the barrow; (*e*) effort to push it forward. Each one of these efforts can be measured separately; thus, Fig. 9A gives some idea how the efforts in *b* and *c* are measured: by a suitable system of levers and springs the latter are made to exert in proportion to the effort applied a pressure on a rubber ball filled with air; this drives the air to a special registering apparatus, the effort being later determined from the reading of the registering apparatus. Another device of a similar nature for measuring the work of a filer is shown in Fig. 9B, one of the uses to which it may be applied being the determination of the value of work of apprentices and unskilled laborers. The curves in Fig. 9C present a full picture of the work of a skilled workman on one side, and an apprentice on the other. Curve VII shows how regular and uninterrupted is the motion of the file in the case of a skilled workman, and how with an

apprentice there are always dead periods between each forward and backward motion of the file. The curves showing the pressure exerted by the left and right hand are of particular interest. With the skillful workman the pressures of the two hands are in perfect accord, very different from the apprentice's curves.

Steam Engineering

CONTRIBUTION TO THE CRITICISM OF PROCESSES OF FLOW IN NOZZLES AND DISTRIBUTORS (*Zur Kritik der Strömungsvorgängen in Düsen und Leitapparaten*, G. Zerkowitz. *Zeits. für das gesamte Turbinenwesen*, vol. 9, no. 25, p. 394, and no. 26, p. 410. September 10 and 20, 1912. 7 pp., 3 figs. *etA*). Development of the theory of flow of gases through nozzles and distributors, with its application to the case of not perfect gases, i.e. of the equations of Professor Stodola (*Dampfturbinen*, 4th ed.) and Dr. Christlein (cp. The Journal, February 1912, p. 310). Owing to lack of space the mathematical reasoning of the author is omitted, and only a condensed report of the main results is presented here.

Denoting the pressure by p, specific volume by v, velocity of flow of the fluid (wet or superheated steam, gas, etc.) by w, heat content by i, velocity of sound by w_s, weight of the fluid flowing through the nozzle or distributor, in kg per sec., by G, cross-section of nozzle by f, and friction work per kg by R, the author obtains the equation

$$\frac{dw}{wdz} = \frac{w_s^2 \dfrac{df}{fdz} - \zeta w^2}{w^2 - w_s^2}$$

where z is the length of the path of flow along the axis of the nozzle and ζ coefficient of resistance which the author defines by a special equation in such a manner as to make it independent of the geometric form of the nozzle section. The above equation gives the variation of velocity as a function of the length of the path of flow, independently of the nature of the flowing liquid, and, together with Stodola's equation, permits a full analysis of the process of flow. This equation permits also of the determination in what part of the nozzle the velocity of flow becomes equal to that of sound. With $w = w_s$, the denominator in the above equation becomes equal to zero, but since the acceleration cannot physically become infinite, the numerator in that equation must also become zero, or

$$\frac{df}{fdz} = \zeta$$

which determines the position of the section of the nozzle at which the velocity of flow is equal to that of sound. Further since $\frac{df}{fdz}$ can have only one positive value, the flow can reach the velocity of sound only at a certain cross-section in the interior of a *divergent* tube. The author further points out that for a cylindrical tube, if the coefficient of resistance were equal to zero, both pressure and velocity would be constant while in a tube with a section of minimum cross-section the "acoustic" section might be expected to coincide with that minimum cross-section, though in prac-

FIG 9A DEVICE FOR MEASURING THE WORK OF A MAN LOADING A WHEELBARROW

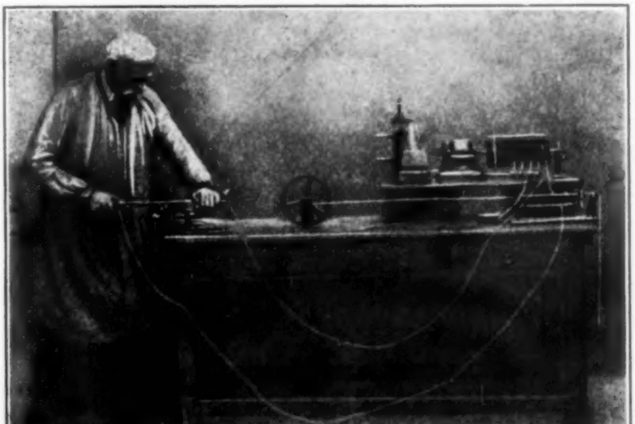

FIG 9B DEVICE FOR MEASURING THE WORK OF A FILER

tice the velocity of flow does not reach that of sound at that section owing to the non-negligible resistances in front of the minimum section observed by Christlein in his Charlottenburg experiments. The difference between the author's formula for the position of the "acoustic" section and that of Lorenz (*Technische Wärmelehre*, 1904) is explained by the fact that while the author deals with velocity of sound, Lorenz uses *adiabatic* velocity of sound. The important distinction between the two is that adiabatic velocity of sound is entirely independent both of the resistances in the piping and the variation of the cross-section along the axis of the pipe, while this cannot be said of the velocity of sound w_s such as the author is using. The author expresses, however, some doubt as to whether either of these sound velocities has really any bearing on the actual process of pressure variations.

By a further investigation of the case of perfect gases the author shows

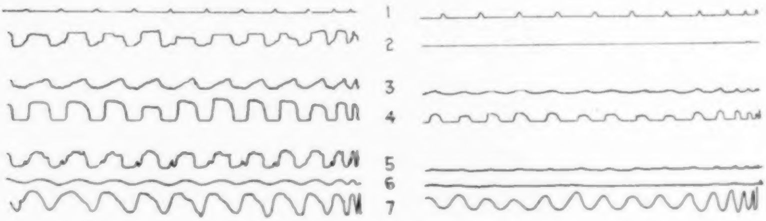

FIG. 9 DEVICES FOR MEASURING THE EFFORTS OF WORKMAN, AND CURVES SHOWING WORK OF A FILER

1 Metronome record
2 Horizontal component of the action of the left hand
3 Vertical component of the action of the left hand
4 Horizontal component of the action of the right hand
5 Vertical component of the action of the right hand
6 Variation of pressure on the vice
7 Forward and backward motion of the file

that the sound velocity w_s, which in the case of polytropic expansion coinsides with the velocity of flow, is a function of the exponent of the polytropic expression, and that it depends further not only on the initial state, but also on resistances.

The second part of the article is devoted mainly to a recapitulation of former experiments on the flow of steam through nozzles and on "clearance expansion" (*Spaltexpansion*), with particular regard to the experiments of Christlein above referred to.

INFLUENCE OF NAPHTHA ON LOCOMOTIVE BOILERS (*Vliyaniye nefti na parovoznye kotly*, B. Artzish. *Bulletin of the Permanent Committee of the Conferences of Representatives of Russian Railroads (in Russian)*, no. 8, p. 700. August 1912. 3 pp., 1 fig. *p*). It was for some time a common practice on the Russian railroads to *pour naphtha* (10 to 40 lb. at a time) *into locomotive boilers* after washing them out or after the boiler was put up for the first time after coming out of the repair shop. Sometimes naphtha (10 to 15 lb.) was introduced into a boiler which had not been washed for a long time, the purpose being to prevent throwing due to

violent formation of steam owing to the dirty condition of the boiler. Generally, however, the naphtha was used because it was supposed to break up the scale in the boiler, and because, carried with the steam into the cylinder, it acted as a *supplementary lubricant for the throttle*, many engineers finding the regular throttle lubrication by the throttle lubricating cup insufficient. It was found that naphtha remains in a boiler some time, and traces of it were found in the water level indicator even after two regular runs.

The author considers such application of naphtha as positively injurious to the boiler, because, as was found in the tests made by Professor Hirsch in Paris, the presence of even a very thin layer of mineral oil on the boiler sheets raises the temperature of the latter considerably, and while the amount of water evaporated was found to fall off about 20 per cent, as compared with the case of the boiler filled with clean water only, the temperature of the boiler sheet was about 180 deg. fahr. higher than in the latter case. This explains why lumps of hard scale separate from the boiler walls more easily in the presence of naphtha, and also why there were so many cases in the Russian boiler practice of fractures of staybolts, cracks in flues, etc., all this being due to overheating produced by the presence of a layer of naphtha on the heating surfaces of the boiler. This is further proved by fractures at the joints of the fire tubes owing to melting of the solder, notwithstanding its being made of two parts copper and one part zinc and melting at 425 deg. cent. (797 deg. fahr.) and higher.

SCALE IN STEAM BOILERS: METHODS OF REMOVING IT AND PREVENTING ITS FORMATION. (*Les incrustations dans les chaudières à vapeur. Remèdes curatifs et préventifs*, Gaillard. *Association des ingénieurs électriciens sortis de l'Institut Electrotechnique Montefiore, Bulletin*, vol. 12, series 3, no. 6, p. 229, June 1912. 70 pp., 25 figs. *gp*). A very complete and interesting discussion and description of various methods of scale prevention and removal, and apparatus used in this connection. Only apparatus of proved practical value or historical interest are considered.

TESTS FOR DETERMINING THE RATING OF HEATING BOILERS (*Versuche zur Ermittlung von Heizkessel-Leistungen*, W. P. *Haustechnische Rundschau*, vol. 17, no. 7, p. 71. October 1, 1912. 3 pp., 4 figs. *ep*). Brief discussion of the proceeding in testing heating boilers based on the respective chapters in the book of de-Grahl: "*Wirtschaftlichkeit der Zentralheizung.*"

SUBSTITUTION OF COMPRESSED AIR FOR STEAM IN OIL BURNING FURNACES (*Substitution de l'air comprimé à la vapeur d'eau dans les foyers à combustible liquide*, Auguste Liévin. *La Technique moderne*, vol. 5, no. 8, p. 294. ½ p., 2 figs. *de*). V. S. Nazaroff, engineer of the Transcaucasian Railroads, Russia, has substituted compressed air for steam in the atomization of liquid fuel, his arrangement as applied to a locomotive being shown in Fig. 10, where *C* is the compressed air tank, *b* fuel pipe, and *B* fuel tank, the fuel used being *mazout*, or residues of rock-oil. The disadvantages which were found in the use of steam for the atomization of liquid fuel consisted in trouble and loss of time in starting; explosions in the

furnace produced by the condensation of some of the derivatives of the fuel used forming highly explosive mixtures, and not infrequently burning the firemen; dissociation of steam in the hottest part of the furnace with the formation of a gaseous mixture which on recombining produced noises like pistol shots. All this is said to be eliminated when compressed air is used instead of steam, and further an economy of 38 per cent in the consumption of fuel is secured. In view of the latter statement the Editor calls attention to the data on the use of compressed air for this purpose contained in Mr. Howard Stillman's paper on Locomotive Practice in the Use of Fuel Oils, Trans. Am. Soc. M. E., vol. 33, 1911, p. 49. The article in *La Technique moderne* does not contain full data of any tests.

CONCERNING HEATING FLUES IN STEAM BOILERS (*Über Heizkanäle im Dampfkessel*, P. Koch. *Der praktische Maschinen-Konstrukteur*, vol. 45, no. 21, p. 358. October 10, 1912. 1½ pp. *p*). In passing from pit coal to lignite or vice versa the grate arrangement is sometimes changed while the heating flue cross-section is left as it is. The author shows by a detailed calculation that the *flue cross-section* which may be entirely satisfactory in one case proves to be wrong in another, and prevents the boiler from utilizing the fuel to its best advantage.

INDUCED DRAFT INSTALLATIONS (*Saugzuganlagen*, G. Hilliger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 35, no. 40, p. 417. October 4, 1912. 2½ pp. *g*). General discussion of the application of induced draft in steam boiler plants, with some particular references to the Prat, Schwabach and Babcock and Wilcox types.

COUNTER CURRENT CONDENSERS FOR DRY CONDENSATION (*Gegenstrom-Kondensatoren für trockene Kondensation*, M. Saalfield. *Der praktische Maschinen-Konstrukteur*, vol. 45, no. 20, p. 334. September 26, 1912. 1 p., 1 fig. and a sheet of drawings. *d*). Description of some German counter current condensers, such as are used in the sugar and chemical industries.

A CONVENIENT CONTROL OF STEAM CONSUMPTION OF TURBINES (*Betriebsmässige Dampfverbrauchskontrolle an Turbinen*, K. Schultze. *Zeits. für das gesamte Turbinenwesen*, vol. 9, no. 28, p. 442. October 10, 1912. 3 pp., 1 fig. *epA*). Absence of a constant control of steam consumption may lead to heavy losses since one leaky valve or steam connection will, in a year's operation, make quite an appreciable difference in the cost of power. On the other hand the only way to control the steam consumption up to now was by means of steam meters, and their heavy cost makes their constant use prohibitive. The author who had to determine the commercial efficiency of a plant in actual operation, and could rely only on such help as the engineer and fireman of the plant could render, with the engineer having to attend not only to two 1000-kw. turbines, but also to an electric switchboard, had to work out some process that might be applied under such conditions and also under the usual operative conditions in commercial plants. His process was based on the fact that, when $p_2 < 0.58p_1$, or ratio of pressures is below the critical limit already in the first distributor, the steam consumption per second is expressed by the formula

$$G_{sec} = C.F_{min} \cdot \sqrt{\frac{P_1}{v_1}}$$

where F_{min} is the minimum cross-section of the distributor in square meters, p_1 pressure in atmospheres absolute immediately in front of the distributor, C turbine constant, which for steam temperatures from 250 to 300 deg. cent. (482 to 572 deg. fahr.) varies between 206 and 208, while v_1 is determined from the equation

$$v_1 = 0.0047\frac{T}{p_1} - 0.075\left(\frac{273}{T}\right)^{\frac{3}{16}} + 0.001$$

where T is the absolute steam temperature in front of the distributor.

The author's experiments were made on two 1000-kw. German General Electric Company, Curtis type, turbines with throttling governing, eight nozzles permanently open, and eight more, in two sets of four nozzles each, opened or closed by hand. Readings were taken every hour by the engineer

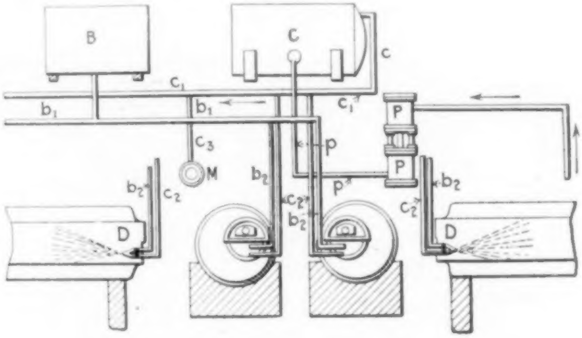

Fig. 10 Nazaroff System of Atomizing Fuel by Compressed Air

or his assistant, who filled out the first, second, fourth and fifth columns of Table 1, the rest of the work being done mostly by slide rule later in the office. The author points out that a large part of this work can be done by girls, and that it takes only 24 minutes to complete a 24-hour table of steam consumption from the data furnished by the engine room. Values of $\frac{p_1}{v_1}$ are not calculated, but determined from a special chart, such as is given in Fig. 11.

It is evident that the correctness of this method depends to a material extent on a correct knowledge of F_{min}, and the author points out that data furnished by the manufacturers are not to be relied on in this respect since contractions in the nozzles are liable to occur either through accumulations of burned oil, or owing to disintegration of the metal itself which partly honeycombs the orifice of the nozzle. This would lead to the calculation indicating a higher consumption of steam than is actually the case, but even that does not deprive the method of its value which lies mainly in indicating fluctuations and thus aiding the discovery of leaks and other irregularities of operation and not in measuring the actual average consumption of steam.

TABLE 1 STEAM CONSUMPTION OF TURBINE NO. 1, FEBRUARY 12, 1912

Time	p_1 Read	p_1 Corrected	t	Nozzles	$\sqrt{\frac{p_1}{v_1}}$	Minutes of Operation	t_0
7	8.9	9.5	284	9.30	6.50	...	....
8	8.1	8.6	283	I	5.96	..	....
9	7.8	8.2	279	10.35	5.75	210	31.1
10	7.9	8.35	289	II	5.79	65	13.7
				1.15	....	...	....
11	7.1	7.4	274	....	5.24	...	....
12	8.4	8.9	300	....	6.00	...	....
1	8.3	8.8	290	....	6.04	160	45.0
					Total	435	89.8

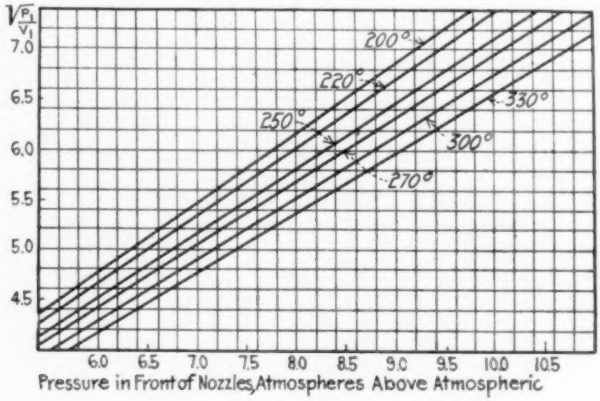

FIG. 11 $\sqrt{\frac{P_1}{V_1}}$ CHART

Strength and Testing of Materials

PORTABLE HYDRAULIC PRESS IN TESTING OF MATERIALS (*Die transportable hydraulische Presse im Materialprüfungswesen*, E. Gebauer. *Tonindustrie-Zeitung*, vol. 36, no. 117, p. 1585. October 3, 1912. 2 pp., 6 figs. *dp*). Description of the portable hydraulic press for testing of materials and its applications. The press installation described consists of the hydraulic press proper with a manometer, a high-pressure hand pump, and beams for placing the press on its foundations. The press is of simple construction, having a long cylinder with a cylindrical piston, with leather packing. The cylinder is made to permit a long useful stroke of the piston, which is of advantage when a long deflection of the piece tested has to be produced, e. g. in the case of a reinforced concrete beam stressed up to rupture. The cylinder is of steel casting, and the whole installation is designed so that pressures up to 300 kg/qcm (4270 lb. per sq. in.) may be

easily maintained, without driving the pump too fast in order to replace losses of water escaping through untight places.

TESTS OF REINFORCED CONCRETE BEAMS (*Versuche mit Eisenbetonbalken*, C. Bach and O. Graf, *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 122-123, 1912. *eA*). Fourth part of the publication of the data of tests made by the authors, with numerous tables and illustrations. This is considered to be among the most thorough European investigations of this matter.

Thermodynamics

DETERMINATION OF THE COEFFICIENTS OF HEAT TRANSMISSION OF PRINCIPAL ISOLATING MATERIALS (*Détermination des coefficients de transmission calorifiques des principaux frigorifuges*, M. K. Biquard. *Le Génie Civil*, vol. 61, no. 25, p. 502. October 19, 1912. *e*). From a paper presented by the author at the second French congress of Refrigeration, at Toulouse in September 1912. He found from tests made at the laboratory of the Conservatoire des Arts et Métiers, in Paris, the following values for the conductivity between 0 and 30 deg. cent. (32 and 86 deg. fahr.):

	Specific Weight.		Coefficient of Conductivity.
	Kg/Cbm.	Lb. per Cu. Ft.	
Kapok (vegetable cotton from Java)	15.7	0.94	0.034
Cork, grains	78	4.7	0.040
Cork with casein, dry	148	8.9	0.044
Charcoal	184	11	0.045
Cork with resin	275	16.5	0.052
Corrugated cardboard	..	...	0.052
White asbestos fiber	57	3.42	0.054
Corrugated asbestos cardboard	...	...	0.072
Cork with casein, wet	280	16.8	0.088
Cork with resin	310	18.6	0.076
Compressed asbestos	1240	74.5	0.220
Compressed cellulose	1425	85.5	0.210
Bricks made of asbestos and calcium sulphate	1143	68.5	0.350
Clinker bricks	1400	84	0.400
Soft rock	1470	88	0.430

By interposing air spaces between vertical layers of the isolating material non-conductive walls may be obtained when using even relatively dense materials. The best thickness of the air spaces varies between 8 and 25 mm (0.314 in. to say 1 in.)

Supplementary References

WAZAU DYNAMOMETER (*The Journal*, May 1912, p. 806). For detailed description see *Reichelt, Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 35, no. 40, p. 420, October 4, 1912.

CONTRIBUTION TO THE PROBLEM OF MECHANICAL TESTING OF SOFT RUBBER (*The Journal*, November 1912, p. 1896). Same article reprinted in *Gummi-Zeitung*, vol. 27, no. 1, p. 2, October 4, 1912. Cp. also paper by Prof. Memmler on Mechanical Tests for Rubber in The Rubber Industry, report of the proceedings of the International Rubber Congress, London 1911, p. 351.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XXII)

ARTICLES IN PERIODICALS[1]

COPPER GAS ENGINE, SOME DETAILS OF THE. *Power*, October 15, 1912. 2 pp., 7 figs. *d*.

Describes a 900-h.p. engine, giving details of design and operation.

DIESEL ENGINED VESSELS, PERFORMANCE OF NOTABLE SEA-GOING, F. Muller Van Brakel. *International Marine Engineering*, September 1912. 3½ pp., 4 figs. *d*.

DIESEL ENGINES, MOTOR SHIP EAVESTONE FITTED WITH CARELS. *International Marine Engineering*, October 1912. 2 pp., 3 figs. *d*.

DIESEL ENGINES, RUSSIAN HIGH-SPEED MARINE, J. Rendell Wilson. *International Marine Engineering*, July 1912. 4 pp., 5 figs. *d*.

DIESEL OIL ENGINE, PROGRESS OF THE, Rudolph Diesel. *Engineering News*, April 4, 1912. 6½ pp., 8 figs.

Read before the Institution of Mechanical Engineers, March 15, 1912.

JUNKERS OIL ENGINE, THE, F. E. Junge. *Power*, October 29, 1912. 3 pp. *d*.

Details of construction and operation of a 1000-h.p. Junkers oil engine.

JUNKERS OIL ENGINE TO MARINE WORK, THE APPLICATION OF THE. *International Marine Engineering*, July 1912. 3 pp., 3 figs. *d*.

LUFT VORWÄRMUNG BEI VERBRENNUNGSKRAFT, A. Nougier. *Die Gasmotorentechnik*, May and June 1912. *dmp*.

On preheating the air for internal-combustion engines.

OIL FUEL, A GREAT RESERVOIR OF, David White. *Engineering News*, October 17, 1912. 2 pp.

Fuel oil resources of the different shales.

OIL MOTOR SHIP, THE MONTE PENEDS, ANOTHER TRANSATLANTIC. *Engineering News*, October 24, 1912. ½ p., 1 fig. *d*.

General description of new vessel of the Hamburg-American line for New York and Rio Janeiro service.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

OIL SHIP CHRISTIAN X, NEW HAMBURG-AMERICAN. *Engineering News*, October 3, 1912. 2 pp., 2 figs.

Describes new vessel driven by two 8-cylinder Diesel engines of 2500 total horsepower.

POWER STATION AT KAMATA, JAPAN, GAS-OPERATED. *Engineering*, September 20, 1912. 7 pp., 16 figs., 1 table. *d.*

SULZER-DIESEL ENGINED SHIP FOR NEW YORK–RIO SERVICE, J. Rendell Wilson. *International Marine Engineering*, October 5, 1912. 5 pp., 9 figs. *d.*

L'UTILIZATION DE LA CHALEUR D'ECHAPPMENT, BRABBÉE. *Die Werkstatts Technik*, March 1, 15, April 1, 1912. 5000 words.

Review by Le Mois Scientifique et Industrielle for June 1912.

REPORTS OF MEETINGS

NEW YORK MEETING, NOVEMBER 12

A meeting of the Society was held in the Engineering Societies Building, New York, on November 12, at which a paper on Measuring Efficiency in Manufacturing, was presented by the author, Edward B. Passano. Mr. Passano advanced a theory that all profit should be treated as an item of expense. All loss, through inefficiency, is a potential or a positive profit to be made in enterprise. A reduction in expense of business increases the actual profit and increases the efficiency. This method keeps constantly before the management the actual value of each unit of production to the organization, and the loss through inefficiency which is a potential or possible profit. When a new method is being tried out, such a system will show the benefits or losses which are expressed in actual profit or loss as the work progresses.

The paper was discussed by Harrington Emerson, H. M. Rowe, president H. M. Rowe Company, Baltimore, J. M. Foster, Leroy Tabor, Edward L. Suffern, public accountant, of New York, Chas. B. Going, Wm. Kent, Howard F. Turrill, of Patterson & Ridgway, New York, F. A. Waldron, F. W. Miller, H. L. Gantt, F. B. Gilbreth, C. Bowyer Vaux, of the Wistar Institute, Philadelphia, and A. Hamilton Church, consulting engineer, of New York.

NEW HAVEN MEETING, NOVEMBER 13

A meeting of the Society was held in New Haven on November 13, 1912, with afternoon and evening sessions. At the first session which opened in the Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, at three o'clock, E. S. Cooley presided, and two papers on the Transportation of Materials in Manufacturing Plants were read by Herbert L. Seward, Jun. Am. Soc. M. E., of the Sheffield Scientific School, and F. C. Bennett of the Stanley Works, New Britain. The former of these was illustrated by lantern slides. These were discussed by C. D. Rice, Harwood Frost, W. S. Huson, Prof. L. P. Breckenridge, E. S. Cooley, Arthur Brewer, C. F. Hutchings, Calvin W. Rice and Mr. Goldstein, of the Link-Belt Company, Philadelphia. A feature of this session was a large collection of catalogues, photographs and books illustrating all types of conveying machinery, and an extensive bibliography of books and articles on the subject, prepared by the library of the Engineering Societies. At the conclusion of this session dinner was served at the Yale Dining Club.

The evening session opened at eight o'clock in the Mason Laboratory and Calvin W. Rice, Secretary of the Society, was introduced by Prof. Charles F. Scott. Mr. Rice spoke on the work of the Society, particularly of the

local branches, and of the coming Annual Meeting and the Joint Meeting to be held in Germany next summer.

C. E. Booth, chairman of the Yale Student Branch, who followed, spoke briefly of the work planned by the students, including an interesting program.

The subject of the evening, Industrial Education, was then presented in two papers, both illustrated by lantern slides, one by Professor Breckenridge and the other by F. J. Trinder, principal of the New Haven State Education Shop, describing the work of the two Connecticut trade schools at New Britain and Bridgeport. The subject was of particular interest locally, as it is now under consideration in New Haven with reference to the public school system.

The entire meeting was largely attended, more than 150 being present, some of whom came from a considerable distance, showing the wide interest aroused by the occasion.

BOSTON MEETING, NOVEMBER 15

At the November meeting of the Society in Boston, held in Edison Hall on Friday, the 15th, Prof. E. F. Miller presided. The paper of the evening, Dry Rot in Timber Used in Slow Burning Construction, was presented by the author, Frederick J. Hoxie.

On account of the extent of the subject Mr. Hoxie confined himfined himself to the types of fungus growth, roughly classed as dry rot, and to their effect on the timber generally used in mill construction, and gave special attention to yellow pine. In the beginning he called attention to the fact that as a result of the continued demand the quality of timber available for mill construction is constantly growing poorer, also to the difficulty of making specifications which should absolutely insure the desired quality of timber being obtained by reason of the wide difference in the character of woods covered by the same commercial designation. He recommended grading of lumber according to the number of annual grain bands and the specific gravity, rather than by the usual botanical designations. While dry rot is not as common as other less troublesome fungi, and is not found as extensively here perhaps as abroad, it was pointed out that it was exceedingly dangerous because of its tendency to develop unobserved in the interior of sticks and at points where they were built into the masonry. The relative susceptibility of heart and sap wood to this infection was touched upon, also effect of the proportion of rosin. It was shown how the infection was spread to sound lumber, both through faults in piling the lumber in yards and also when assembled in the building. The author called attention to some steps which might be taken to check the infection when once started, and suggested that usually when infection became noticeable, injury had already gone so far as seriously to weaken the structure. Preventive measures were more strongly recommended and several processes of treatment of lumber were discussed.

At close of the written paper Mr. Hoxie showed a large number of slides illustrating the development of the fungus in lumber and the contributory part played by the rot in ruined structures. Several of these slides were

from micro-photographs showing very clearly the spread of the fungus through the structure of the stick.

Charles T. Main. Mem. Am. Soc. M. E., referred to the mischievous effects of painting timbers in buildings before they had opportunity to become thoroughly seasoned, and discussed at length several processes for preserving lumber. Further discussion was offered by Dwight Seabury, Mem. Am. Soc. M. E., R. A. Hale, member of the Boston Society of Civil Engineers, and others.

STUDENT BRANCHES

ARMOUR INSTITUTE

A meeting of the Armour Student Branch was held on November 6, at which Mr. Roesch, a member of the faculty, presented a paper on Carbureters and Mixing Valves, covering mixing appliances for gas engines and a large number of carbureters adapted to automobile work. In addition to lantern slides, Mr. Roesch showed a number of carbureters, parts of which were cut away. The paper was discussed by E. R. Burley, H. A. Bohlander, E. S. Libby, H. R. Kuehn, Chas. Kehr, and D. A. Drozeski.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on October 30 reports on power plant experience were read by L. Grossbaum and Howard Swallow, and practical work in the shops and drafting rooms of representative manufacturing establishments was described by J. Stuart and Mr. Senkstaken.

LEHIGH UNIVERSITY

A paper on Natural Gas Investigations in the Bureau of Mines, by George A. Burrell, was read at a meeting of the Mechanical Engineering Society of Lehigh University on October 22, and discussed by Mr. Mart and Professor De Schweinitz; and another on the Fatigue Failure of Metals, by G. B. Upton and G. W. Lewis, was read and discussed by Mr. Spencer.

OHIO STATE UNIVERSITY

The members of the Ohio State University Student Branch were guests of Prof. F. E. Sanborn, Mem. Am. Soc. M. E., on October 21, when the regular meeting of the organization was held. Prof. Wm. T. Magruder, Mem. Am. Soc. M. E., was unanimously chosen Honorary Chairman of the branch. An illustrated account of his trip through England and Scotland was then given by Professor Magruder, and a general discussion followed.

PENNSYLVANIA STATE COLLEGE

The following officers have been elected for the year by the Pennsylvania State College Student Branch: President, Jonas F. Blank, Vice-President, Wm. E. Evans, Secretary, Guy W. Barger, and Treasurer, Gordon R. Reese. At the first meeting of the branch for the season, held on October 18, addresses were made by Dean J. P. Jackson, and Professors Hugo Diemer, J. A. Moyer, A. J. Wood and J. A. Mease, Members Am. Soc. M. E.

POLYTECHNIC INSTITUTE OF BROOKLYN

On November 12, an illustrated lecture on the 1910 Expedition to Mt. McKinley by J. H. Cuntz was given before the Polytechnic Student Section. A discussion followed in which Henry Priester, B. L. Heustis, Mr. Adler and others participated.

SIBLEY COLLEGE

At the first meeting of the Sibley College Student Branch on October 10 Prof. D. S. Kimball, Mem. Am. Soc. M. E., spoke on Pittsburgh and Its Industries, before a large audience. Dr. William Kent, Mem. Am. Soc. M. E., addressed the meeting of October 30 on the Value of Affiliation and also on Educational Efficiency.

UNIVERSITY OF ARKANSAS

The following officers were elected on October 15 at the University of Kansas for the year 1912-1913: Honorary Chairman, B. N. Wilson, President, Minto McGill, Vice-President, J. G. Buerkle, and Secretary, Claude Bethel. An impromptu debate on the subject, Resolved that the reciprocating engine is more efficient than the steam turbine for sizes below 500 h.p., followed.

At a meeting on November 5, Minto McGill opened a discussion on high-carbon steel, in which various members of the branch participated.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch held on November 1, in which the Student Branch of the American Institute of Electrical Engineers joined, Mr. Fishback, sales maanger of the Electrical Controller Company of Cleveland, gave an illustrated lecture on the Handling of Iron and Steel by Electrical Methods.

UNIVERSITY OF ILLINOIS

Charles R. Velzy (Student 1914) addressed a meeting of the University of Illinois Student Branch on October 26, on the Life of James Watt, which was illustrated with lantern slides. On November 12, Mr. A. S. Buyers of the mechanical engineering department talked on the Theory and Use of the Slide Rule. A general discussion followed.

UNIVERSITY OF KANSAS

A meeting of the University of Kansas Student Section was held on October 24, at which Prof. C. M. Young, of the Mining Engineering Department, read a paper on Explosives, Nature and Composition, which the members joined in discussing. Two papers, The Production of Petroleum Oils, by W. H. Tangeman (Student 1910), and Oil Burners, by Earl Carson (Student 1912), were presented at the meeting of November 7 and discussed by those present.

UNIVERSITY OF NEBRASKA

A paper on Manometer and Piezometer Tubes, by Prof. J. D. Hoffman, Mem. Am. Soc. M. E., was presented at a meeting of the University of Nebraska Student Branch on November 5, and was discussed by L. C. Lichty and B. E. Morley.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of " men available " is made up from members of the Society and good men not members. Information will be sent upon application.

POSITIONS AVAILABLE

0223 Department manager wanted in a large works near New York, making light metal products of high grade, to organize, direct and control the movement of product through the plant, including regulation of stock and shipment of orders. Experience in mechanical and electrical engineering preferred, and training in up-to-date methods of organization, system and management essential. Give age, education, experience and references. Apply through Society.

0224 Works superintendent for plant employing 400 men, manufacturers of Corliss engines and other heavy machinery. Entire charge of plant will be given competent superintendent. Apply through Society.

0225 Commercial engineers for lubricating oil business. Should be technically inclined, with good selling experience and acquaintance with manufacturers. New York State and Connecticut.

0226 Assistant to purchasing agent, to take care of engineering specifications and contracts and act as consulting engineer; position calls for general experience in mechanical engineering and in all matters relating to construction. Location New York State.

0227 Competent engineer as assistant to chief engineer in charge of power plants, regular steam and electrical equipment and large amount of both absorption and compression types of refrigerating machinery. Thoroughly competent man. Location New York State.

0228 Expert on design of automatic machinery, who has been successful along this line.

0229 Young man, technical education, few years' practical experience in connection with boiler room work, for testing and investigating along lines of perfecting combustion.

0230 Tool designer, experienced man on modern cutting shapes and heat treatment, capable of maintaining tool equipment in most economical manner and supervising tool room work. State fully experience, present employment and salary.

0231 High class draftsman and designer of factory layout and special

machinery, to carry out ideas in highly confidential capacity. Prefer man of at least 15 years' experience in shop practice and designing. Apply through the Society.

0232 Competent man to take charge of experimental department working in touch with the manufacturing department in view of devising and remodeling all types of harvesting machinery, including tillage implements. One who has had large experience in the field preferred, or a mechanical engineer with extensive shop experience in designing and constructing various types of machinery and capable as an organizer and superintendent.

0233 Designer capable of handling draftsmen and producing results. Certain amount of shop experience would be an advantage, with experience in industrial plant work. State salary expected and give complete references. Apply through the Society.

0234 Mechanical engineer having experience in designing and knowledge of locomotive work, one preferred who has specialized in stoker design and manufacture.

0235 Chief of bureau of gas and lighting for eastern city. One with the education of a chemical engineer with training and experience of a business man preferred. Apply through the Society.

MEN AVAILABLE

538 Life member, 35 years' experience in designing cutting machines and all apparatus including extracting and evaporating devices for putting raw material into marketable products of dye and farming woods, desires position. Has installed plants for economical utilization of spent wood for generating steam used in the plant.

539 Member, age 34, wide experience in design, construction and supervision of power plants, piping systems and general factory engineering, desires position as works engineer. Power plant economy and efficiency a specialty.

540 Mechanical engineer or superintendent for large corporation; experience along broad mechanical and steam power lines; executive, with ability to handle large number of men, or will consider proposition to act as consulting engineer.

541 Assistant general manager, at present employed in this capacity, technical graduate, 16 years' experience in combined manufacturing and engineering sales work, seeks responsible executive position, preferably with a concern manufacturing a standardized product rather than special work.

542 Junior, 30 years of age, Stevens graduate, desires position as publicity manager for concern manufacturing engineering machinery, or position of similar nature. Has had three years' experience, editor of trade paper, also general business experience.

543 Mechanical engineer, experienced in design, construction and maintenance, competent to act as works engineer.

544 Member, 23 years' experience on rolling mills, miscellaneous steel works, hydraulic and special machinery, desires responsible position. Competent to take entire charge of engineering department in any works building the above lines of machinery.

545 Member with 15 years' broad mechanical experience, at present employed as sales engineer, desires change. Qualified for assistant superintendent, chief draftsman, estimator or sales engineer.

546 Member, technical graduate, age 37, married, wants position as manager. At present employed. Has had practical, manufacturing and sales experience, both as superintendent and as sales manager. Has thorough knowledge of production, costs and manufacturing processes. Would prefer nominal salary with percentage of profits.

547 Mechanical engineer, age 32, married, with initiative, resourcefulness and executive ability; technical education and experience in design, construction and erection, estimating, valuations, purchases and testing; investigations and reports, general and special machinery and industrial plant equipment, special proficiency in internal combustion motors. Prefers location in moderate sized Eastern city. Salary $3000.

548 Junior member, 29, married, twelve years' experience in shop drawingroom and foundry, five years in executive positions, wishes position as assistant superintendent or engineer. Good organizer, designer of automatic machinery and foundry equipment for large production. Thoroughly acquainted with operation of grey iron and malleable foundries. Salary $1800.

549 Mechanical engineer, member, university graduate, 25 years' experience in the building, erection and managing of sugar and chemical plants, designing and building special apparatus, vacuum and condensing plants, power plants, etc., will consider position as superintendent, managing engineer of industrial plants, or take charge of branch office for equipment of such plants.

550 Junior member, technical graduate, experience in fire protection and operating department of large light and power company, desires position with manufacturing concern or consulting engineer.

551 Technical graduate, M.E. and C.E. Wishes to take charge of machine design or descriptive geometry departments of a university or technical school. Has been professor for a number of years in machine design and descriptive geometry, and is author of recent text-books on these subjects. Would accept position as mechanical or research engineer in manufacturing plant, consulting and testing work. At present employed.

552 Junior member, with three years' experience in heating and ventilating work and power plant installations would associate with architect's or consulting engineer's office, taking charge of some line of work. Graduate of a leading Eastern technical school. At present employed.

553 Junior, age 30 years, technical graduate, with experience in design, construction, operation and maintenance of power plants and substations, and in testing electrical and other machinery, desires responsible position with large manufacturing plant or with contractors doing power plant or hydroelectric work. Salary $175-$200 per month.

554 Mechanical engineer, extensive practical shop and commercial experience, expert in up-to-date manufacture of interchangeable machinery, can reduce costs and increase production. At present employed.

555 Associate, age 35, desires position in Philadelphia or vicinity. At

present employed as checker in drawingroom. Experienced in civil, structural and mechanical lines.

556 Mechanical engineer with general engineering, construction, railroad and factory experience desires position. Recently engaged in valuation work.

557 Technical graduate experienced in selling, sales supervision and organization desires executive sales position. Competent in design, operation and sale of power plant equipment, including water purification.

558 Member, graduate mechanical engineer, age 39, married, desires position as superintendent, plant engineer or purchasing agent. Has technical and commercial knowledge in machine shop and foundry practice. At present employed. Location near New York. Salary $3500.

559 Member, technical graduate, B.S. and M.E., at present employed. Lighting, heating and ventilation preferred, but not insisted upon.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

American Ceramic Society. Trans. vol. 14. *Columbus, 1912.* Gift of society.

American Society of Civil Engineers. Index to Trans. vols. 1-74, 1867-1911. *New York, 1911.*

The American Society of Mechanical Engineers. Trans. vol. 33, 1911. *New York, 1912.*

American Wood Preservers' Association. Pro. 8th Annual Meeting, 1912. *Baltimore, 1912.* Gift of association.

Amerikanische Hüttenwerke, Peter Eyermann. *Wein, 1912.* Gift of author.

British Fire Prevention Committee. Red Book no. 169. *London, 1912.*

Cambridge (Mass.) Water Board. Report for the year ending March 31, 1912. *Boston, 1912.* Gift of board.

Carels-Diesel Engine. Gift of W. R. Haynie.

Concrete Highways. *Philadelphia, 1912.* Gift of Association of American Portland Cement Manufacturers.

Electric Lighting and Miscellaneous Applications of Electricity. Wm. S. Franklin. *New York, The Macmillan Co., 1912.*

This volume is particularly interesting in that although it is a text book for the use of students, the first chapter covers installation and operation costs and the selling price of electrical energy, thus entering in the very beginning into a discussion of the most important part of electrical engineering. Professor Franklin's book, which is intended to be a companion volume to his Dynamos and Motors, is evidently intended to be used by his students in Lehigh University.

Electric Power from the Mississippi River. Bull. Nos. 1-7, 1911-1912. *Keokuk, 1911-12.* Gift of B. H. Parsons.

Elementary Machine Drawing and Design. Wm. C. Marshall. *New York, McGraw-Hill Book Co., 1912.*

Professor Marshall's book has been planned for students in engineering who have had a previous course in orthographic projection, but who have not yet become acquainted with simple machine elements. It is primarily a text book for the students in the Sheffield Scientific School of Yale University, but will undoubtedly find large acceptance in other engineering schools.

Energy and Velocity Diagrams of Large Gas Engines, Their Use and Lay-Out, Paul L. Joslyn. *Cincinnati, Gas Engine Publishing Co., 1912.*

In this book the author gives the methods of laying out energy and velocity diagrams for large engines operating on blast furnace, producer or natural gas, with instructions as to their use, etc. The data given are the result of actual designing of this character on some of the largest engines built in America and Europe and will be found of inestimable advantage to the designer working on engines of this character.

DIE ENTROPIE-DIAGRAMME DER VERBRENNUNGSMOTOREN EINSCHLIESSLICH DER GASTURBINE, P. Ostertag. *Berlin, 1912.*

DIE EXISTENZ DER MOLEKÜLE. EXPERIMENTELLE STUDIEN, The. Svedberg. *Leipzig, 1912.*

FLOOD WALL AND MODERN WHARF. Location and Description. *Pittsburgh, 1912.* Gift of Flood Commission of Pittsburgh.

FORSCHERARBEITEN AUF DEM GEBIETE DES EISENBETONS. Pt. 20. *Berlin, 1912.*

GRINDING WHEELS. *Hartford, 1912.* Gift of Travelers Insurance Co.

HETCH HETCHY WATER SUPPLY FOR SAN FRANCISCO, 1912. REPORT, John R. Freeman. *San Francisco, 1912.* Gift of John R. Freeman.

IOWA STREET AND INTERURBAN RAILWAY ASSOCIATION. Pro. 8th Annual Convention, 1911. *Davenport, 1912.* Gift of association.

JAHRBUCH DER MOTORLUFTSCHIFF STUDIENGESELLSCHAFT. 1907-1908, 1909-1910. *Berlin.*

MANCHESTER STEAM USERS' ASSOCIATION. Memorandum by Chief Engineers 1911. *Manchester, 1912.* Gift of association.

MARKET STREET EXTENSION RAPID TRANSIT TUNNEL, UNDER TWIN PEAKS RIDGE, REPORT ON, Bion J. Arnold. Preliminary Report No. 8, submitted October 7, 1912. *1912.* Gift of author.

MECHANICAL ENGINEERING LABORATORY MANUAL, Earl B. Smith. Ed. 2. *Philadelphia, Drexel Institute Press, 1912.* Gift of author.

The author states that his endeavor has been to give a few experiments along different lines that would serve to the best advantage the purpose of educating young engineers, and not to give them a great store of information but to teach them principles. Experiments on the strength of materials and on cement testing has been left for another volume. Some of the experiments contained in the first edition, which was issued in 1909, have been omitted, several have been revised and a few added to the second edition.

MECHANISM, R. McA. Keown. *New York, McGraw-Hill Book Co., 1912.*

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK. Report 1912. *New York, 1912.* Gift of commission.

MODERNE TECHNIK, H. Blücher. 2 vols. *Leipzig, 1912.*

MODERNE WINDTURBINEN, Otto Stertz. *Leipzig, 1912.*

MOTEURS À DEUX TEMPS, L. Ventou-Duclaux. *Paris, 1912.*

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION. Official Report. May 1911, October 1911, Atlantic City, New York 1911.

NATIONAL RIVERS AND HARBORS CONGRESS. Pro. 8th Annual Convention, 1911. *Cincinnati, 1912.*

NEW YORK STATE EDUCATION DEPARTMENT. Souvenir of the Dedication of the New York State Education Building, October 15-17, 1912. *Albany, 1912.* Gift of department.

DER PORTLAND CEMENT UND SEINE ANWENDUNGEN IM BAUWESEN, F. W. Büsing and C. Schumann. *Berlin, 1912.*

PRACTICABILITY, UTILITY AND BENEFIT OF RAILROADS. Inland Transit, N. W. Cundy. Ed. 2.

PROCURING AND MAINTAINING FOREIGN PATENTS. *Washington, 1910.* Gift of Alexander and Dowell.

THE RUDDER. vol. 16, 1905. *New York, 1905.*

ST. LOUIS RAILWAY CLUB. Official Pro., vol. 1, nos. 1-9; vol. 2, nos. 1-10; vol. 3, nos. 1-11; vol. 4, nos. 1-2; vol. 5, nos. 1-12; vol. 6, nos. 1-12; vol.

7, nos. 1-12; vol. 8, nos. 1-12; vol. 9, nos. 1-12; vol. 10, nos. 1-12; vol. 11, nos. 1-5, 7-12; vol. 12, nos. 1-12; vol. 13, nos. 1-10, 12; vol. 14, nos. 1-12; vol. 15, nos. 1-2, 4-5, 7, 9-12; vol. 16, nos. 1-12. *St. Louis, 1896-1912.* Gift of St. Louis Railway Club.

SCIENTIFIC AMERICAN. vol. 2, nos. 1-2. *New York, 1846.*

SOUTHWESTERN ELECTRICAL AND GAS ASSOCIATION. 6th Annual Convention. Papers, Reports and Discussions, May 12-14, 1910. *Dallas, 1910.* Gift of association.

DAS STEINKOHLENGAS IM KAMPF GEGEN DIE VERSCHWENDUNG DES NATIONALVERMÖGENS, Franz Messinger. *1911.*

TEXT BOOK ON ROADS AND PAVEMENTS, Frederick P. Spaulding. Ed. 4. *New York, J. Wiley & Sons, 1912.*

STREET PAVEMENTS AND PAVING MATERIALS. A Manual of City Pavements: the Methods and Materials of Their Construction. Geo. W. Tillson. Ed. 2. *New York, John Wiley & Sons, 1912.*

The interest of the mechanical engineer in the subject of roads and pavements must be due largely to the effect on these surfaces of the modern automobile. Professor Spalding's work deals rather with the country road than with the city pavement, whereas Mr. Tillson's work confines itself almost entirely to the city pavements. The latter contains an interesting chapter on the construction of street car tracks in paved streets and roadways which should be of interest to the engineer for electric railways, and also a chapter on the protection of pavements, a subject which is not given the attention it should have in the United States of America. Both of these works are distinct contributions to the subject and should receive the attention of all engineers.

THE TOSI STEAM TURBINES. Constructed by F. Tosi. Reprinted from *Engineering*, April 26, 1912. *London, 1912.*

LA TURBINA À VAPORE "TOSI" MARIA, F. Modugno. *Roma, 1912.*

UNIVERSITY OF PITTSBURGH. OUTLINE OF THE SMOKE INVESTIGATION. Bull. No. 1, August 1912. Gift of R. C. Benner.

WESTERN RAILWAY CLUB. Official Pro. 1911-1912. *Chicago, 1912.* Gift of club.

WHAT IS A MILLION DOLLARS TO THE CITY OF NEW YORK, ANYWAY? Correspondence with Mayor Gaynor regarding Tunnel Construction, Duncan D. McBean. Gift of author.

WORKING PLAN FOR FOREST LAND BELONGING TO THE CITY OF NEW BEDFORD ON THE WATERSHEDS OF GREAT AND LITTLE QUITTACAS PONDS. *New Bedford, 1912.* Gift of R. C. P. Coggeshall.

UNITED ENGINEERING SOCIETY

GESCHAFTS-BERICHT DER DEUTSCHEN BUCHDRUCKER BERUFS GENOSSENSCHAFT Jahr 1911. *Frankfort-on-Main, 1911.* Gift of Deutschen Buchdrucker Berufs Genossenschaft.

UNITED STATES CATALOG BOOKS IN PRINT JANUARY 1, 1912. Ed. 3. *Minneapolis-New York, H. W. Wilson Co., 1912.*

EXCHANGES

ECOLE D'APPLICATION DU GÉNIE MARITIME. COURS DE MACHINES À VAPEUR. Vol. 1, 1910-1911.

——— Cours de Construction du Navire. Tome II, 1910-12. N.p. n.d. (Exchange.)

INSTITUTION OF CIVIL ENGINEERS OF IRELAND. Trans. vol. 38. *Dublin, 1912.*

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND. Trans. vol. LV. *Glasgow, 1912.* (Exchange.)

INSTITUTION OF NAVAL ARCHITECTS. Trans. vol. 54, 1912. *London, 1912.*

TRADE CATALOGUES

AMERICAN METER CO., *Erie, Pa.* Catalogue of metric metal works, 1909.

J. M. DODGE CO., *Philadelphia, Pa.* Cat. 1912, 96 pp.

HESS BRIGHT MFG. CO., *Philadelphia, Pa.* Vertical shaft, Sheet 13A, Class I; marine propeller shaft ball bearings, Sheet 86; mounting for double exhaust fan, Sheet 87, Class X; two direction thrust bearings, medium weight series no. 2100, Sheet 49B, Class III; numerical index to data sheets, July 1912; classified index to titles, data sheets, July 1912.

INGERSOLL-RAND CO., *New York.* Temple-Ingersoll electric air rock drills, instructions for installing and operating, 34 pp.; 5-F Temple-Ingersoll electric air drill, instructions for installing and operating with duplicate part list, 22 pp.; Temple-Ingersoll electric air rock drills, descriptive, April 1912, 15 pp.; Temple-Ingersoll electric air rock drill, type 4-E, July 1912, 3 pp.; type 5-F, July 1912.

METRIC METAL WORKS, *Erie, Pa.* Wescott gas and air meter.

NORTH WESTERN EXPANDED METAL CO., *Chicago, Ill.* Expanded metal construction, Bull. No. 10, Nov. 1912.

OTTO GAS ENGINE WORKS, *Philadelphia, Pa.* Catalogue describing the Otto horizontal crude oil engine, type DH 50, 16 pp.

PARKESBURG IRON CO., *Parkesburg, Pa.* Descriptive catalogue, 43 pp.

PYOTT CO., *Chicago, Ill.* Pulley catalogue and price list, 1912, 111 pp.

UNDER-FEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity magazine, Oct. 1912.

WESTINGHOUSE MACHINE CO., *East Pittsburgh, Pa.* Circular W.M.501, Aug. 1909.

WHITING FOUNDRY EQUIPMENT CO., *Harvey, Ill.* Cat. No. 99, foundry cranes and equipment.

YALE & TOWNE MFG. CO., *New York.* Hoists, the triplex block.

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EXTRACTS FROM THE BOOK OF THE

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Multi-stop and Double Turners

FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

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FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

HARTNESS FLAT TURRET LATHE

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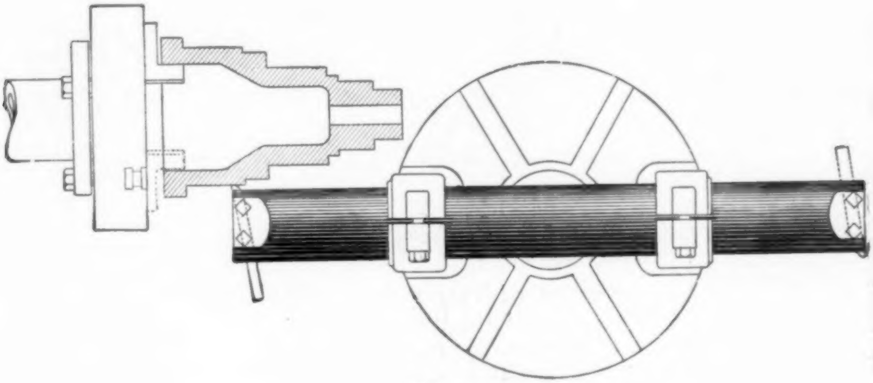

FIG. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

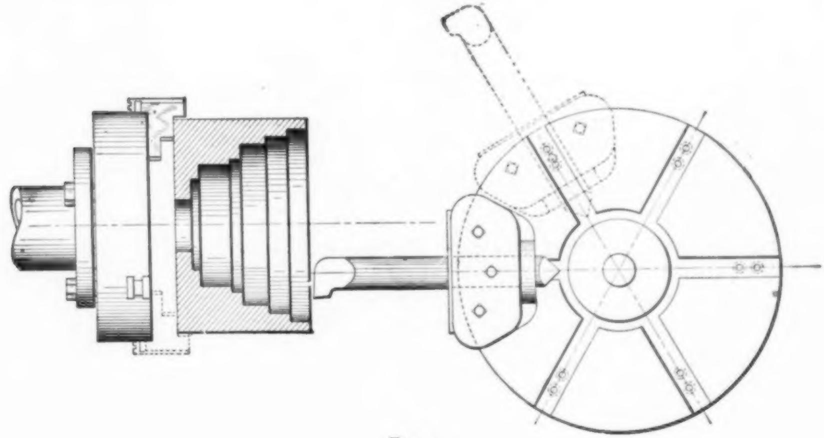

FIG. 3

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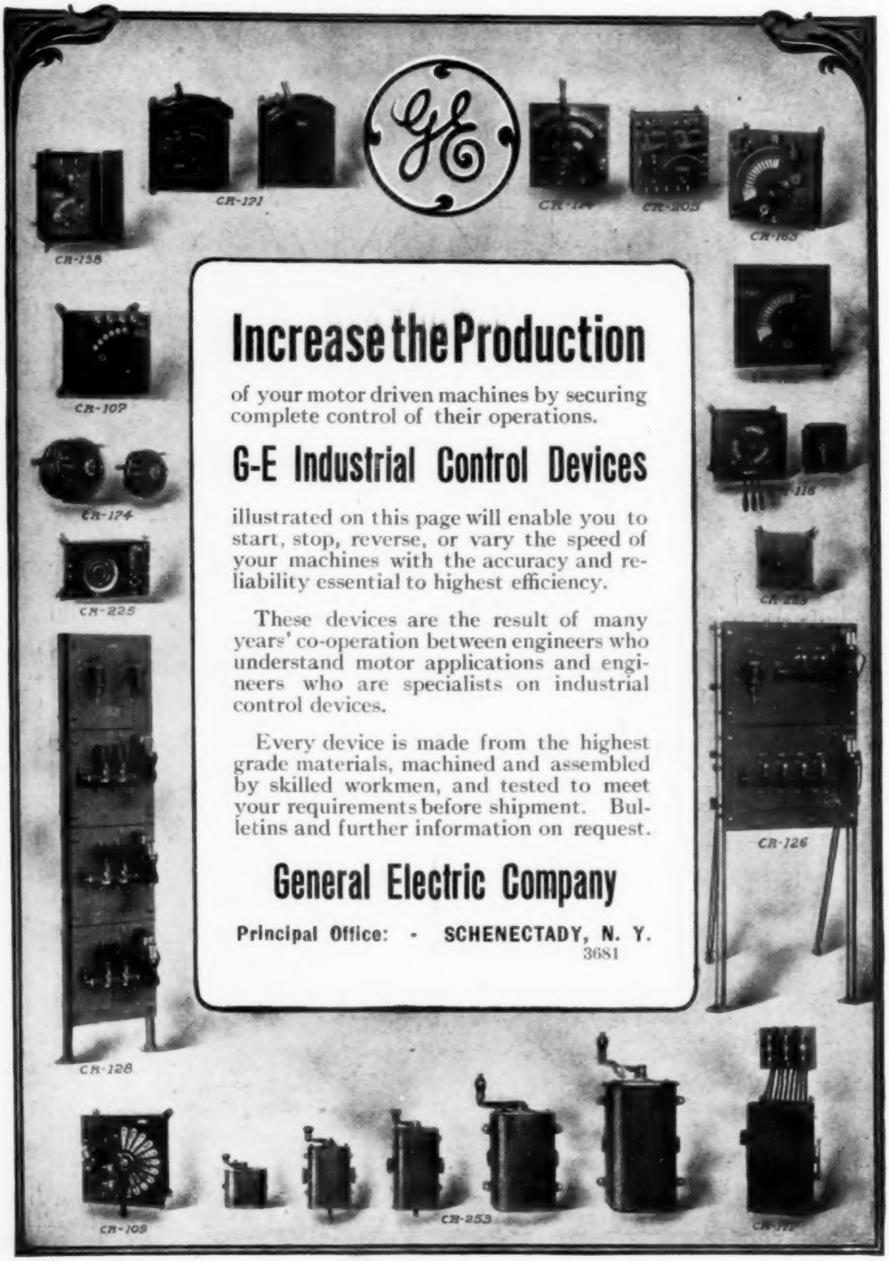
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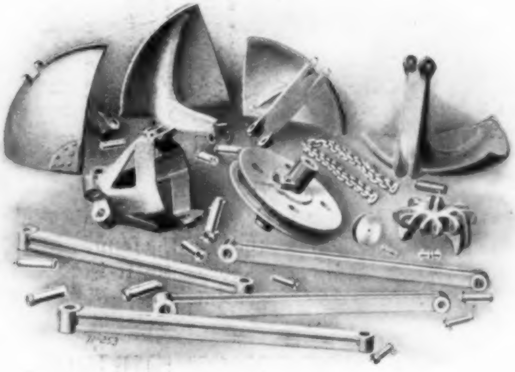

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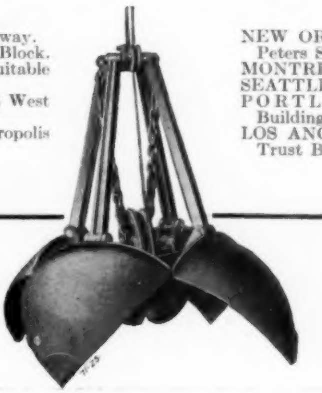

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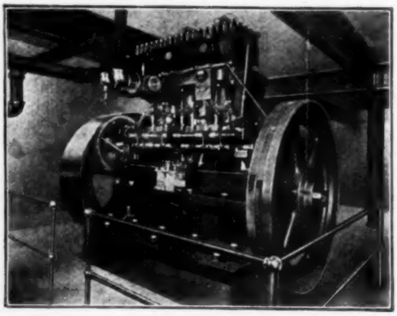

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